VAX BASIC User Manual

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This manual describes how to develop VAX BASIC programs, describes the features of the language, and describes how to use VMS features from VAX BASIC programs.

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Preface

Intended Audience

This manual presents tutorial information on VAX BASIC language features and describes how to develop and use VAX BASIC programs on VMS systems. Readers are presumed to have some previous knowledge of BASIC or another high-level programming language. This manual should be used with the other two manuals in the documentation set.

Associated Documents

This manual is one of three manuals that form the VAX BASIC document set. The other two manuals are:

VAX BASIC Reference Manual	Provides reference material and syntax for all VAX BASIC language elements except graphics capabilities
Programming with VAX BASIC Graphics	Provides tutorial and reference material for VAX BASIC graphics capabilities

You may also be interested in the following supplementary manuals:

- *VAX BASIC Syntax Summary*
- *Introduction to BASIC*
- *BASIC for Beginners*
- *More BASIC for Beginners*

Document Structure

This manual has 23 chapters and 3 appendixes. The chapters are grouped into three parts as follows:

Developing VAX BASIC Programs on VMS

Chapter 1	Provides a brief overview of VAX BASIC
Chapter 2	Shows you how to get started on VMS
Chapter 3	Describes how to develop programs in the BASIC environment
Chapter 4	Describes how to develop programs from DCL command level and how to generate a compiler listing
Chapter 5	Describes how to use the VMS Debugger to debug VAX BASIC programs

VAX BASIC Programming Concepts

Chapter 6	Explains the elements of VAX BASIC programs
Chapter 7	Explains simple input and output procedures
Chapter 8	Shows how to use VAX BASIC arrays
Chapter 9	Explains data definitions
Chapter 10	Explains how to create user-defined data structures with the RECORD statement
Chapter 11	Shows how to control the flow of program execution
Chapter 12	Explains how to use VAX BASIC functions
Chapter 13	Explains how to handle strings in VAX BASIC
Chapter 14	Describes structured VAX BASIC programming techniques
Chapter 15	Explains how to manage files
Chapter 16	Describes how to format output with the PRINT USING statement
Chapter 17	Explains error handling techniques
Chapter 18	Shows how to use compiler directives
Chapter 19	Describes how to represent data on VMS systems

Using VAX BASIC Features on VMS

Appendixes

Conventions

Convention	Meaning
$ BASIC prog1	The hardcopy version of this manual has interactive examples that show user input in red letters and system responses or prompts in black letters. The online version differentiates user input from system responses or prompts by using a different font.
. . .	A vertical ellipsis indicates that code which would normally be present is not shown.
UPPERCASE letters	Uppercase letters are used for VAX BASIC keywords and must be coded exactly as shown.
lowercase letters	Lowercase letters are used to indicate user-supplied names or characters.

Summary of Technical Changes

Summary of New and Changed Features for Version 3.4

Version 3.4 of VAX BASIC includes support for the Program Design Facility (PDF). This new functionality can be implemented by appending the /DESIGN qualifier to the DCL command BASIC. See Chapter 4 for more information on the /DESIGN qualifier.

In addition, this documentation update contains numerous corrections and clarifications to previous documentation. These documentation changes do not reflect new features.

Part I
Developing VAX BASIC Programs on VMS

Chapter 1

Overview of the VAX BASIC Language

This brief overview highlights the features of the VAX implementation of BASIC. The features listed here are described fully in subsequent chapters of this manual, as well as in the other two manuals in the documentation set.

BASIC was originally developed for students with little or no programming experience. Since then, BASIC has become one of the most widely used programming languages and is available on almost every computer system. The VAX implementation of BASIC has evolved beyond the original design; however, VAX BASIC still supports all of the traditional features of the original language in addition to more recent programming techniques. It has become much more than a teaching tool, and is used in a wide variety of sophisticated applications.

VAX BASIC is a powerful structured programming language designed for novice and application programmers alike. The language provides you with both a highly interactive programming environment and a high-performance development language. VAX BASIC supports such language constructs as:

- Code without line numbers (traditional line numbers are optional)
- Control structures, such as SELECT CASE
- Explicit variable declarations
- Capabilities for handling dynamic strings
- Adaptable file-handling capabilities for terminal-format files, and the full range of RMS facilities
- Global and local run-time error handling with WHEN ERROR blocks
- Compile-time directives
- A variety of data types, including packed-decimal and user-defined records

- Extensive error checking with meaningful error messages
- Thirty-one-character names for variables, labels, functions, and subprograms

VAX BASIC uses the VMS operating system to its full advantage and is integrated with many other DIGITAL products. In particular, VAX BASIC supports:

- Interactive graphics[1]
- The VAX standard calling procedures
- Record definitions included from the VAX Common Data Dictionary
- Code analysis with the VAX Performance and Coverage Analyzer (PCA)
- Creation of code with the VAX Language-Sensitive Editor
- Extensive online language help
- Exchange of data with other systems using DECnet

VAX BASIC supports the features of other versions of BASIC, including PDP–11 BASIC-PLUS-2. VAX BASIC is a functional superset of BASIC-PLUS-2. Compatibility flags for BASIC-PLUS-2 and ANSI Minimal BASIC allow you to check whether your VAX BASIC programs will run on other systems.

When you write programs in VAX BASIC, you can choose between two program development methods: developing programs at DCL command level, or developing programs from within the BASIC environment. When you develop programs at DCL level, you write your source program with a text editor, then compile, link, and run the program with commands to the VMS operating system. Alternatively, when you develop programs within the BASIC environment, you simply type the DCL command BASIC to enter the environment, enter your program, then execute it with the VAX BASIC command RUN.

The chapters in this part of the manual show you how to get started on the VMS system and how to develop programs both at DCL command level and within the BASIC environment.

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[1] The optional graphics capabilities are discussed in *Programming with VAX BASIC Graphics.*

Chapter 2

Introduction to the VMS Operating System

When you develop VAX BASIC programs on the VMS operating system, you use commands that are part of the DIGITAL Command Language (DCL). This chapter explains how to use a VMS system. More specifically, this chapter discusses how to:

- Log in to and out of the VMS system
- Access the HELP facility
- Use DCL commands
- Create directories and subdirectories
- Use DCL file-handling commands
- Develop command procedures
- Develop VAX BASIC programs

For a complete list of DCL commands, see the *VMS DCL Dictionary*.

2.1 Logging In and Out

Before you can log in to the VMS operating system, you must have an account set up in your name. Your system manager is generally the person responsible for establishing this account and will provide you with both your user name and password. Both of these are unique to your session and distinguish you from other users on the system. Once you are an authorized user, you can regularly access the system.

When you log in, the system prompts you for your user name and password. When you enter your user name, each character is displayed, or *echoed*, at the terminal. However, when you enter your password, no characters are

echoed. This enables you to protect your account from others who may try to access it. For example:

```
RET
Username: SMITH RET
Password:       RET

$
```

The system uses the dollar sign ($) as a prompt. When this prompt is displayed, it indicates that the login procedure was successful and that you can begin entering commands. If you enter your user name or password incorrectly, the system displays an error message. To gain access to the system, you must repeat the login procedure.

To change your password, type the SET PASSWORD command and press the RETURN key as shown in the following example. The system prompts you for your current password. The system then prompts you for your new password, which can have up to 31 characters with any combination of the letters A through Z, the numbers 0 through 9, a dollar sign ($), and an underscore (_).

```
$ SET PASSWORD          RET
Old password:           RET
New password:           RET
Verification:           RET
```

To verify that you have entered your password correctly, the system prompts you to enter your new password again. If the two new passwords do not match, your original password remains in effect.

To end the current session, enter the LOGOUT command:

```
$ LOGOUT
```

The system responds with the following message:

```
SMITH logged out at DD-MMM-YYY HH:MM
```

2.2 Accessing the HELP Facility

The VMS system has an online HELP facility that is useful if documentation on a particular command is not readily available. To gain access to the HELP facility, you use the DCL command HELP. For example:

```
$ HELP RET
```

The system displays a list of topics for which help is available and prompts you for a topic. If you want information on a specific command, such as the DCL command BASIC, type that command after the topic prompt. For example:

```
Topic? BASIC [RET]
```

The system displays a description of the command, and lists all the available VAX BASIC qualifiers, parameters, and other topics for which help is available. It then prompts you for a subtopic.

```
BASIC Subtopic? /SHOW [RET]
```

If you already know which subtopic you want information on, you can type the HELP command followed by the BASIC topic and the subtopic you want help on. For example:

```
$ HELP BASIC/SHOW [RET]
```

Note that all language HELP is available only from within the BASIC environment or from within the VAX Language-Sensitive Editor.

To exit from the HELP facility, press CTRL/Z. Once the dollar sign prompt is displayed, the system is ready to accept a new command.

2.3 Entering and Editing DCL Commands

Once you have gained access to the system, you can use DCL commands to perform specific tasks. DCL commands are words, generally verbs, that describe the action they perform. Following are some of the most important rules for using DCL commands. Other rules are described in the *VMS DCL Dictionary*.

- You can typically truncate any command name or qualifier name to four characters. Fewer than four characters is acceptable if the truncated name is unique to the command that you want.
- You must precede each qualifier name with a single slash character (/).
- You can type commands in either upper- or lowercase letters.
- If you omit a required parameter (for example, a file specification), the DCL command interpreter will prompt you for it.
- You can type a command on as many lines as you wish, as long as you end each line (except the last) with a hyphen (–).
- After you have typed a complete command line, you must press RETURN to execute the command.

If you enter a command incorrectly (for example, if you misspell a command or qualifier name), the command interpreter issues an error message and you must either retype the entire command or edit the command and then reenter it. Command-line editing enables you to correct errors in lengthy command lines and saves you the trouble of retyping the entire line.

To edit DCL command lines, you can use various control characters as well as keypad keys. The following list describes some of these editing functions:

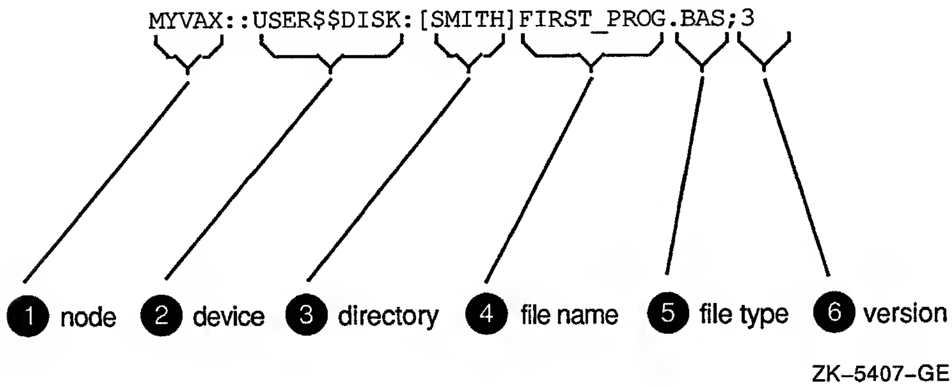
DELETE	Moves the cursor back one character and erases that character.
Up arrow/(CTRL/B)	Displays the most recent command line entered. You can display up to twenty previously entered command lines by continuing to press CTRL/B or the up arrow key. To display command lines in the opposite direction, press the down arrow key.
Left arrow/(CTRL/D)	Moves the cursor one position to the left.
Right arrow/(CTRL/F)	Moves the cursor one position to the right.
CTRL/U	Deletes the current command line and issues a carriage return so you can reenter the entire command line.
CTRL/C and CTRL/Y	Cancels or interrupts an entire command line.

2.4 Understanding the Directory Structure

A directory is a catalog of files. Each file is distinguished by its name, file type, and version number. It is not necessary to specify the complete file specification every time you compile, link, or run a source program. Under most conditions, it is necessary to specify only the file name.

Figure 2–1 illustrates a complete file specification.

Figure 2–1: Complete File Specification



1. Specifies a computer system that is part of a DECnet network.
2. Identifies the hardware device on which the file is either stored or written.
3. Specifies the directory in which a file is cataloged.
4. Distinguishes a file from others contained in the same directory. A file name can have up to 39 characters.
5. Identifies the type of data that a file contains.
6. Specifies the version number of a file. Each time a file is modified, its version number is incremented by 1.

When you log in to the VMS operating system, you enter your default directory, which generally has the same name as the account you log in to. This default directory is also called your main or top-level directory. The system allows you to create subdirectories from your main directory. Subdirectories are helpful in organizing files. For instance, if you are a multilanguage user, it may be helpful for you to keep all of your VAX BASIC programs separate from your VAX COBOL programs. To create a subdirectory, you issue the DCL command CREATE/DIRECTORY. In the following example, the directory BASIC_PROG.DIR is created. You can then specify the subdirectory name [SMITH.BASIC_PROG] in commands or programs.

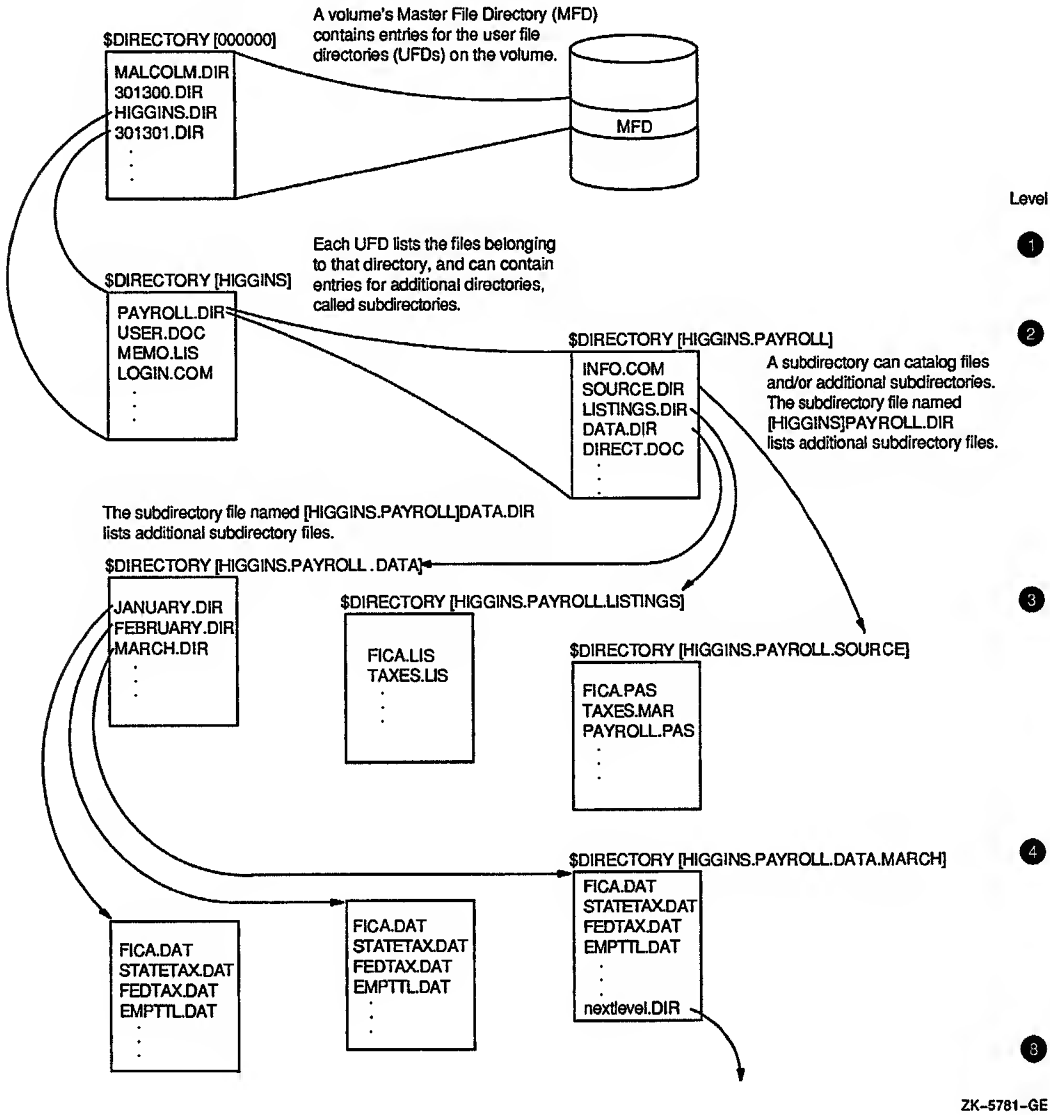
```
$ CREATE/DIRECTORY [SMITH.BASIC_PROG]
```

To move from one directory to another, you use the SET DEFAULT command as shown in the following example:

```
$ SET DEFAULT [SMITH.COBOL_PROG]
```

The number of subdirectories you can create is limited only by the amount of disk space you have available. Figure 2–2 illustrates the concept of directory hierarchies.

Figure 2–2: A Directory Hierarchy



Often, you may refer to files that are contained in your directory hierarchy but that are not contained in your current default directory. Two special symbols exist to make references easier: the ellipsis (...) and the hyphen (–). The ellipsis is used to search down a directory hierarchy and the hyphen is used to search up a directory hierarchy.

For instance, [SMITH...] refers to the directory [SMITH] and all of the subdirectories below [SMITH] in the hierarchy. The directory specification, [...BASIC_PROG], refers to all subdirectories named BASIC_PROG below the current default directory. You can specify the current default directory with empty brackets ([ ]), and you can refer to the entire hierarchy under your current default directory with [...].

Hyphens allow you to search up the hierarchy one directory at a time; each hyphen stands for one level. For example, if your current default directory is [SMITH.BASIC_PROG], you can refer to [SMITH] by specifying [–].

To delete a subdirectory, you must first remove any files that are contained in it and change the protection on the directory file. You can then delete the .DIR file.

Note that you can use both square brackets and angle brackets interchangeably to refer to directories.

For a more detailed discussion of the directory structure, see the *Introduction to VMS.*

2.5 Using DCL File-Handling Commands

DCL file-handling commands allow you to modify and maintain your source programs. The following sections describe how to use DCL commands to perform common file operations such as displaying files, printing and typing files, deleting files, purging files, renaming and moving files, searching files, and setting file protection.

For a complete list of qualifiers to each command and for more detailed information, see the *VMS DCL Dictionary* or type HELP at the DCL prompt followed by the name of the command.

2.5.1 Displaying Files

To display a list of all the files that are contained in a directory, you use the DCL command DIRECTORY. When you enter the DIRECTORY command with no parameters or qualifiers, the system displays an entire list of all the files that are contained in your current directory. For example:

```
$ DIRECTORY

Directory USER$$DISK:[SMITH]

PROG1.DIA;22     PROG1.EXE;2      PROG1.OBJ;50      PROG1.BAS;53
```

If you want to know how many versions of a specific file exist in your current directory, you enter the DIRECTORY command along with a specific file name and file type as shown in the following example:

```
$ DIRECTORY PROG1.BAS

Directory USER$$DISK:[SMITH]

PROG1.BAS;53

Total of 1 file.
```

The system displays a list of all the versions of the file that currently exist.

However, if you wish to view only a selected group of files that contain a specific file type, you can use an asterisk (*) or a percent sign (%) as a wildcard character. The asterisk signifies any number of characters, including zero, whereas the percent sign signifies exactly one character. Therefore, *.BAS represents all files that end with the file type BAS, whereas 3%.BAS represents only those files that contain two characters for a file name, where 3 is the first character. For example:

```
$ DIRECTORY  *.OBJ

Directory USER$$DISK:[SMITH]

PROG1.OBJ;53      PROG2.OBJ;54      PROG4.OBJ;55

Total of 3 files.
```

The system displays only those files that end with the file type OBJ.

2.5.2 Printing and Typing Files

To examine the contents of a file, you can use either the DCL command PRINT or the DCL command TYPE. The PRINT command allows you to output the contents of a file to a line printer, whereas the TYPE command allows you to output the contents of a file to your terminal screen.

In the following example, the PRINT command outputs the file FIRST_PROG.BAS to a printer:

```
$ PRINT FIRST_PROG.BAS
```

By default, the system prints the most current version of FIRST_PROG.BAS. To print a specific version of FIRST_PROG.BAS, you must specify a version number. For instance, in the following example, the system prints the second version of FIRST_PROG.BAS:

```
$ PRINT FIRST_PROG.BAS;2
```

With the PRINT command, you can specify command qualifiers. For example, the /AFTER qualifier specifies that the job not be printed until a specific time of day. For a complete list of all the command qualifiers available with the PRINT command, see the *VMS DCL Dictionary*.

With the TYPE command, you can display the contents of a file on your terminal screen. If you specify the /PAGE qualifier, you can display one screen of text at a time. If you do not specify the /PAGE qualifier, you can press CTRL/S to interrupt the display for closer examination of a particular section and then resume the display by pressing CTRL/Q. If your keyboard has a NOSCROLL or a HOLD SCREEN key, you can use it to toggle between interrupting and resuming the display.

2.5.3 Deleting Files

To delete a file, you use the DCL command DELETE. With the DELETE command, you must specify the file name, the file type, and the version number of the file you want to delete. For instance, in the following example, the system deletes the first version of FIRST_PROG.BAS:

```
$ DELETE FIRST_PROG.BAS;1
```

If you want to delete all versions of a file, you can use an asterisk (*) as a wildcard character. For example:

```
$ DELETE FIRST_PROG.BAS;*
```

Similarly, if you want to delete all files with a particular file type, you can use the asterisk (*) or the percent sign (%) as a wildcard character. For instance, in the following example, the system deletes all files that have the file type LIS:

```
$ DELETE *.LIS;*
```

You can specify command qualifiers with the DELETE command. For instance, if you specify /CONFIRM, a request is issued before each individual DELETE operation so that you can confirm that the operation should be performed on a particular file.

2.5.4 Purging Files

The DCL command PURGE deletes all but the most recently modified version of files. Unlike the DELETE command, you can specify the PURGE command without specifying a file name or file type. The system deletes all files except the most recent version in your current directory.

```
$ PURGE
```

By default, only the most recent version of each file is kept. You can, however, specify the number of versions that are kept by specifying the /KEEP qualifier. This command qualifier specifies the maximum number of versions of a specified file to be kept in your directory. For instance, in the following example, the system deletes all but the two highest versions of FIRST_PROG.BAS:

```
$ PURGE FIRST_PROG.BAS/KEEP=2
```

2.5.5 Renaming and Moving Files

To change the identification of one or more files, use the DCL command RENAME. For instance, in the following example, FIRST_PROG.BAS is changed to SECOND_PROG.BAS:

```
$ RENAME FIRST_PROG.BAS SECOND_PROG.BAS
```

Note that because a version number is not specified, the most current version is renamed by default.

You can also use the RENAME command to move a file from one directory to another. For instance, in the following example, the file SECOND_PROG. BAS is moved from the directory [SMITH] to the subdirectory [SMITH.BASIC_PROG]:

```
$ RENAME [SMITH]SECOND_PROG.BAS [SMITH.BASIC_PROG]
```

To move an entire set of files that have a common file name or file type, you can use the asterisk (*) as a wildcard character. For instance, the following command line changes the directory name of all files that contain the file name SECOND_PROG:

```
$ RENAME [SMITH]SECOND_PROG.*;* [SMITH.BASIC_PROG]*.*;*
```

2.5.6 Searching Files

To search a file or a group of files for a specified string, use the DCL command SEARCH. This command allows you to search the contents of a specified file or group of files for a particular string or strings and lists all the lines in which the string or strings appear. In the following example, the directory [SMITH.BASIC_PROG] is searched for any files that contain the string "Course_Data":

```
$ SEARCH [SMITH.BASIC_PROG]*.*;* "Course_Data"
```

2.5.7 Setting File Protection

To prevent others from gaining access to a file, you use the SET FILE/PROTECTION command. With this command, you specify user categories with access types. Table 2–1 lists the four user categories and Table 2–2 lists the four access types.

Table 2–1: File Protection User Categories

User Category	Description
OWNER	The user who created the file
GROUP	All users, including the owner, who have the same group number in their user identification codes (UICs) as the owner of the file
WORLD	All users
SYSTEM	All users who have the same system privilege (SYSPRV), or low group numbers (usually from 1 through 10)

Table 2–2: File Access Variations

Access	Description
READ	The ability to examine, print, or copy a file
WRITE	The ability to modify or write a file

(continued on next page)

Table 2–2 (Cont.): File Access Variations

Access	Description
EXECUTE	The ability to execute a file that contains executable program images
DELETE	The ability to delete a file

When you specify the SET FILE/PROTECTION command, the class names and access types can be spelled out or abbreviated to the first letter. For example, you may want to give system users and your project members complete access to the file TEST.BAS, and give others read access only. To do this, you would enter the following command:

```
$ SET FILE TEST.BAS/PROTECTION = (S:RWED,O:RWED,G:RWED,W:R)
```

2.6 Using Command Procedures

A command procedure is a group of DCL commands in a file that can be executed by the DCL command interpreter. You can use command procedures to generate sequences of command lines that you type frequently. For example, you could create a command procedure that compiles, links, and runs your source programs while checking for error status. Moreover, you could create a command procedure that deletes all files that end with a particular file type. Instead of typing each command separately, you would execute the command procedure.

The following sections briefly discuss the rules for defining DCL symbols and logical names as well as how to create and execute a command procedure. In addition, this section contains a sample command procedure and a sample LOGIN.COM file. For more information, see the *Guide to Using VMS Command Procedures*.

2.6.1 Defining DCL Symbols and Logical Names

You define a symbol by placing the equal sign (=) or the double equal sign (==) between the symbol and the string it represents. If you use the double equal sign operator, the system inserts the symbol in the global symbol table; if you use the equal sign operator, the system inserts the symbol in a local symbol table. When a symbol is local, it is recognized only within the procedure in which it is contained. However, when a symbol is global, it is recognized by many other procedures.

For example, the following command defines the global symbol BASIC as a command to invoke the VAX BASIC compiler, with two added qualifiers:

```
$ BASIC == "BASIC/DEBUG/LIST"
```

Briefly, the VMS system creates a global symbol table for you when you log in. Then, each time you execute a command procedure, the system creates a new command level and a local symbol table for that level. If one command procedure executes another procedure, the system creates another new—lower—command level and another local symbol table, and so forth. Every command level can access the symbols in the global symbol table, as well as symbols in local symbol tables at higher command levels. In other words, you can define local symbols in a command procedure that are available to lower-level procedures. The *VMS DCL Dictionary* describes symbol tables in detail.

Note that the system discards local symbols and their values when a procedure exits. A command procedure can create local symbols, but the symbols are deleted when the procedure ends. However, when you define local symbols at DCL command level, these symbols remain until you explicitly remove them or until you log out.

You can pass information to a higher-level command procedure by defining a global symbol to contain the information. Because there is only one global symbol table, and it is accessible at all command levels, the higher-level command procedure can test the value of the symbol.

To allow abbreviations of a symbol, insert an asterisk (*) in the symbol where you want to end the acceptable abbreviation. For example, if you wanted to abbreviate the command BASIC to BAS, you could define a symbol as follows:

```
$ BAS*IC == "BASIC/DEBUG/LIST"
```

Once you have defined this symbol, you can type BAS (plus any remaining letters in the command) to invoke the VAX BASIC compiler with the /DEBUG and /LIST qualifiers. Note that the double equal sign in this symbol definition causes the creation of a global symbol.

You can determine the definition of a symbol by typing SHOW SYMBOL, followed by the symbol name. For example:

```
$ SHOW SYMBOL BAS
  BAS*IC == "BASIC/DEBUG/LIST"
```

To delete a symbol, type DELETE/SYMBOL, followed by the symbol name. If you do not specify a symbol table qualifier, /LOCAL is the default. If the symbol is in the global table, type DELETE/SYMBOL/GLOBAL followed by the symbol name. For example, you could delete the symbol BAS*IC that you had previously defined, by typing the following:

```
$ DELETE/SYMBOL/GLOBAL BASIC
```

To create a logical name, you use either the DCL command DEFINE or the DCL command ASSIGN. A logical name is a name that is equated to an equivalence string, or a list of equivalence strings. For example, the following command assigns the logical name INFO to the file specification USER$$DISK:[SMITH]INFO.DAT;12:

```
$ DEFINE INFO USER$$DISK:[SMITH]INFO.DAT;12
```

You can determine the definition of a logical name by typing SHOW LOGICAL, followed by the logical name. For example:

```
$ SHOW LOGICAL INFO
  "INFO" = "USER$$DISK:[SMITH]INFO.DAT;12" (LNM$PROCESS_TABLE)
```

When you create a logical name, it is maintained in a logical name table. For more information on logical name tables, see the *VMS DCL Dictionary*.

You can keep a file of symbols and logical names for the system to define every time you log in, thus creating a set of personal commands for special purposes. For information on login command procedures, see Section 2.6.4.

2.6.2 Creating and Executing Command Procedures

To create a command procedure, you can invoke a text editor or you can use the DCL command CREATE. If you use the default file type COM, you need not include the file type when you execute the procedure.

Once you have created your command procedure, you can execute it either interactively or in batch. To execute a command procedure interactively, type the at sign (@) execute procedure command followed by the name of the file. In the following example, the procedure SAMPLE.COM is executed:

```
$ @SAMPLE
```

To execute a command procedure in batch, you use the DCL command SUBMIT. This command allows you to submit your procedure to a system batch job queue for execution. Once the job completes, the system prints a log file indicating the status of the job and then deletes the log file from your

directory. In the following example, SAMPLE.COM is placed in the system batch job queue. A log file entitled SAMPLE.LOG will be created.

```
$ SUBMIT SAMPLE
```

2.6.3 Sample Command Procedure

Example 2–1 is included to help you understand how command procedures can aid in the programming process. This command procedure incorporates many of the DCL commands discussed throughout this chapter. Any text that follows an exclamation point (!) is interpreted by the DCL command interpreter as a comment and is ignored.

Example 2–1: Sample Command Procedure

```
$ !The following command procedure tests to see if the file name you
$ !input exists.  If it does exist, the procedure will automatically
$ !compile, link, and run your source program.  If the file does not
$ !exist, the procedure will ask you if you want to create the file.
$ !If you respond YES, the default text editor is invoked so that you
$ !can create the source file.
$ !
$ !
$ IF P1 .EQS. "" THEN INQUIRE P1 "FILE NAME"
$ FILETYPE = ".BAS"
$ FILESPEC = P1 + FILETYPE                                    ➊
$ IF F$SEARCH(FILESPEC) .EQS. "" THEN GOTO MESSAGE
$ SHOW SYMBOL FILESPEC
$ !
$ !
$ !
$ ON ERROR THEN GOTO PRINT_ROUTINE
$ WRITE SYS$OUTPUT "Compiling..."                             ➋
$ BASIC/LIST 'P1'
$ !
$ !
$ WRITE SYS$OUTPUT "Linking..."                               ➌
$ LINK 'P1'
$ !
$ !
$ WRITE SYS$OUTPUT "Running..."                               ➍
$ SET NOON
$ DEFINE/USER_MODE SYS$INPUT SYS$COMMAND
$ RUN 'P1'
$ GOTO END
$ !
$ !
```

(continued on next page)

Example 2–1 (Cont.): Sample Command Procedure

```
$ PRINT_ROUTINE:                                                    ❺
$   WRITE SYS$OUTPUT "Error in program - processing stops"
$   PRINT 'P1'
$ END:
$ !
$ PURGE
$ !
$ EXIT
$ !
$ MESSAGE:                                                          ❻
$   WRITE SYS$OUTPUT "Can't find requested file"
$   INQUIRE ANS "Do you want the file created?"
$   IF ANS .EQS. "YES" THEN GOTO EDIT_ROUTINE
$ EXIT
$ !
$ EDIT_ROUTINE:                                                     ❼
$   DEFINE/USER_MODE SYS$INPUT SYS$COMMAND
$   WRITE SYS$OUTPUT "Invoking editor..."
$   EDIT FILESPEC
$ EXIT
```

❶ Marks the beginning of the command procedure and prompts the user for a source file name if the user has not supplied one. If the file is not found, control is transferred to a routine called MESSAGE.

❷ Marks the start of the compilation process. The procedure outputs an informational message and invokes the VAX BASIC compiler.

❸ Marks the start of the linking process. Again, the procedure outputs an information message and invokes the VMS Linker.

❹ Marks the start of the running process. Once again, the procedure outputs an informational message and runs the program. The input device is equated to the user's terminal to allow data to be entered.

❺ Identifies the actions of the command procedure in the event an error occurs during execution. When an error does occur, control is transferred to this routine. The procedure outputs an informational message and prints the LIS file.

❻ Marks the routine that alerts the user that the source file has not been found. If the user chooses to create the file, control is transferred to the routine called EDIT_ROUTINE.

❼ Marks the start of the edit routine. Again, the input device is equated to the user's terminal to allow data to be entered. The procedure then outputs an informational message and creates the supplied source file by invoking the user's default text editor.

2.6.4 Login Command Procedures

If you are a frequent user of the VMS system, you may find that you are typing the same long command lines on a regular basis. To avoid such repetition, you can create a special command procedure that contains these commands and statements. This special command procedure is called a LOGIN.COM file.

When you log in, the system automatically searches your default device and directory for a file named LOGIN.COM. If the file exists, the system automatically executes the commands within that file.

A LOGIN.COM file might appear as follows:

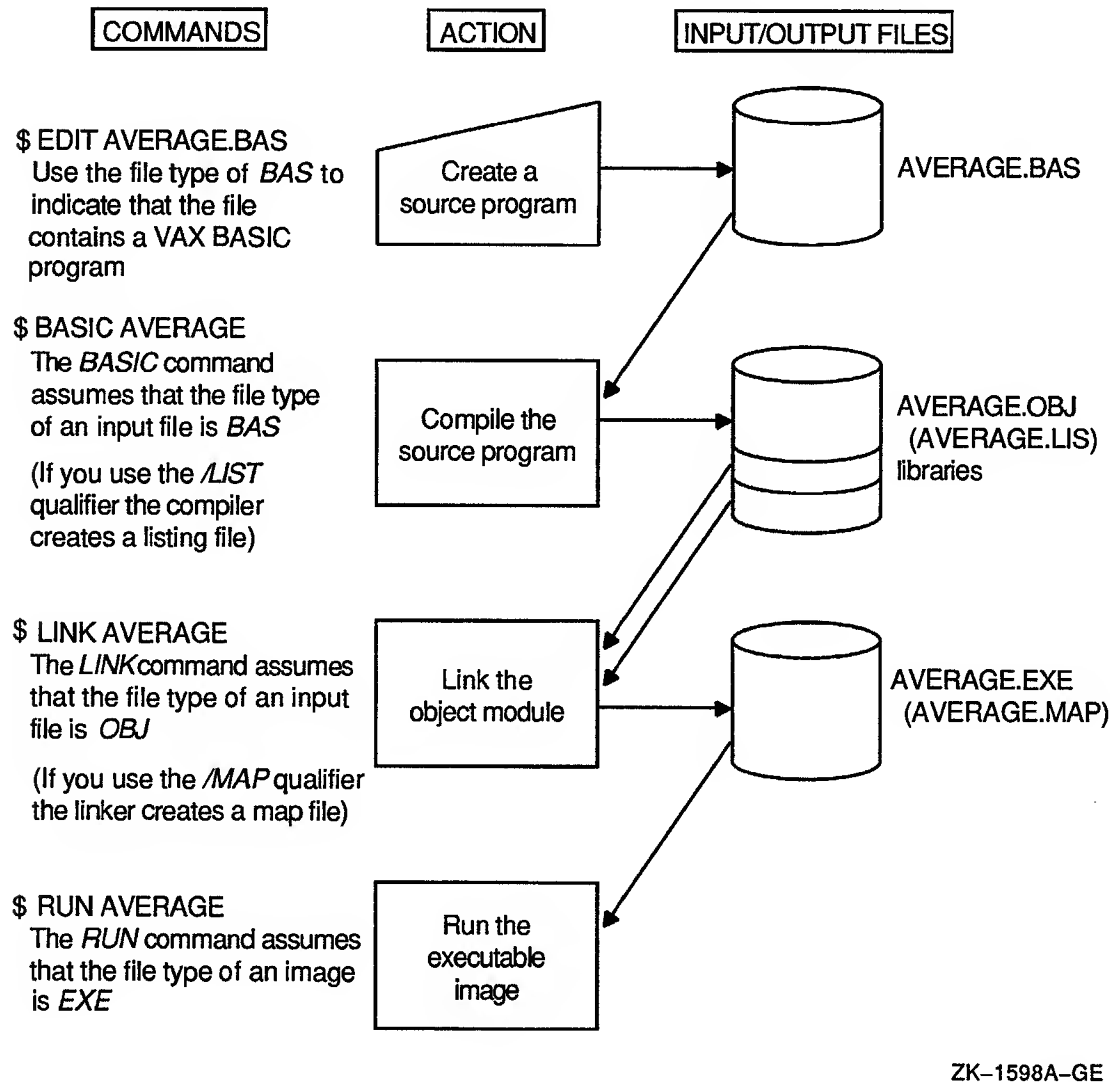
```
$ !If the current process is noninteractive then exit
$ IF F$MODE().NES. "INTERACTIVE" THEN EXIT
$ !
$ !*****************************************
$ !*        Convenient Commands            *
$ !*****************************************
$ !
$ PURGE == "PURGE/KEEP=2/CONFIRM"
$ ST == "SHOW TIME"
$ QUE == "SHOW QUEUE"
$ M*AIL == "MAIL"
$ !
$ !*****************************************
$ !*       Symbols for my directories      *
$ !*****************************************
$ !
$ HOME == "SET DEFAULT [SMITH]"
$ WORK == "SET DEFAULT [SMITH.WORKSP]"
$ EXAMPLES == "SET DEFAULT [SMITH.PROG_EXAMPLES]"
$ !
$ !*********************************************************
$ !* Logical names for the people I frequently send mail to *
$ !*********************************************************
$ !
$ DEFINE JEN MYVAX::BROWN
$ DEFINE SUE MYVAX::KELLY
$ DEFINE BOB MYVAX::CONNELL
$ EXIT
```

For more information on creating a login command file, see the *Guide to Using VMS Command Procedures*.

2.7 DCL Commands for Program Development

VAX BASIC can function as both a standard compiler or as a programming environment. When using VAX BASIC as a standard compiler, you create programs at DCL command level. This section describes the DCL commands that are used to create, compile, link, and run a VAX BASIC program on a VMS system. These commands are illustrated in Figure 2–3. For a more detailed description of each command, see Chapter 4. For more information on using VAX BASIC as a programming environment, see Chapter 3.

Figure 2–3: DCL Commands for Developing Programs



The following example shows each of the commands shown in Figure 2–3 executed in sequence:

```
$ EDIT/AVERAGE.BAS
$ BASIC AVERAGE
$ LINK AVERAGE
$ RUN AVERAGE
```

To create a VAX BASIC source program at DCL level, you must invoke a text editor. In the previous example, the VAX EDT editor is invoked to create the source program AVERAGE.BAS. You can, however, use another editor, such as the VAX Text Processing Utility (VAXTPU) or the VAX Language-Sensitive Editor. BAS is used as the file type to indicate that you are creating a VAX BASIC source program. BAS is the conventional file type for all VAX BASIC source programs.

When you compile your program with the BASIC command, you do not have to specify the file type; VAX BASIC searches for BAS by default.

If your source program compiles successfully, the VAX BASIC compiler creates an object file with the file type OBJ. However, if the VAX BASIC compiler detects errors in your source program, the system displays each error on your screen and then displays the DCL prompt. You can then reinvoke your text editor to correct each error.

You can include command qualifiers with the BASIC command. Command qualifiers cause the VAX BASIC compiler to perform additional actions. For instance, in the following example, the /LIST qualifier causes the VAX BASIC compiler to produce a listing file:

```
$ BASIC/LIST FIRST_PROG
```

For a complete list and explanation of all the command qualifiers available with the BASIC command, see Chapter 4.

Once your program has compiled successfully, you invoke the VMS Linker to create an executable image file. The VMS Linker uses the object file produced by VAX BASIC as input to produce an executable image file as output.

You can specify command qualifiers with the DCL command LINK. For a complete list and explanation of all the command qualifiers available with the LINK command, see Chapter 4.

Once the executable image file has been created, you run your program with the DCL command RUN.

Chapter 3

Developing Programs in the BASIC Environment

The BASIC environment has capabilities and features that make the process of program development easier for both novice and expert users. This chapter describes how to work within the BASIC environment.

3.1 Entering the Environment

To enter the BASIC environment, type the DCL command BASIC and press RETURN. VAX BASIC responds with an identification line and the Ready prompt:

```
$ BASIC RET
VAX BASIC V3.4

Ready
```

Once you are in the BASIC environment, you interact directly with the compiler. In this mode of operation, you can enter any of the following:

- VAX BASIC program lines
- Immediate mode statements
- Compiler commands and qualifiers

When you enter program statements, VAX BASIC stores them in ascending line number sequence as part of the current program in memory. If you enter a program line with the same line number as an existing program line, the new line replaces the old one.

When you create a program in the environment, the first line of the program must have a line number. If you enter a subsequent program line without a line number, you must precede it with a space or a tab. Inside the environment, only those program lines that begin with line numbers can start in the first character position on a line.

NOTE

> To develop programs in the environment that have no line numbers at all, you must use an editor or copy your program into the environment with the OLD command.

If a program line is too long for one text line, you can continue it by typing an ampersand (&) and pressing RETURN. (Note that only spaces and tabs are valid between the ampersand and the carriage return.)

See Section 3.3 for more information about immediate mode statements and Section 3.5 for more information about VAX BASIC compiler commands.

3.2 Creating and Running Programs

Inside the BASIC environment, there are two ways to type in and edit a program. You can type in and edit the program directly using line mode, or you can use the compiler command EDIT to invoke a text editor when you are in the environment.

The EDIT command invokes the default text editor for your system. After entering the BASIC environment, you can type the EDIT command, create your program with a text editor, and then exit from this editor back to the environment. At this point, the program you created is the current program in memory, and you can now type RUN or RUNNH to compile, link, and execute your program. (RUNNH suppresses header information such as the name of the program and the time of day.)

You also have the option of creating your program with a text editor accessed from DCL. In this case, once you have created the program, you can either enter the BASIC environment and use the OLD command to read your program into memory, or compile your program at DCL level. Chapter 4 discusses how to compile your programs at DCL level.

The following example shows a simple program being entered and run in the environment. The program accepts three numbers entered at the terminal, averages them, and displays the result.

Example

```
$ BASIC

VAX BASIC V3.4

Ready

NEW FIRSTTRY

Ready
```

```
10  PRINT "Please enter three numbers"
        INPUT A, B, C
        PRINT "Their average is"; ( A + B + C ) / 3
        END
RUNNH
```

Output

```
Please enter three numbers
?  5
?  10.3
?  4.7
Their average is 6.66667
Ready
```

In the preceding example, the DCL command BASIC invokes VAX BASIC and places you in the BASIC environment. The compiler command NEW informs VAX BASIC that you want to create a new program and assigns the program a name. Here the program is named FIRSTTRY.BAS. If you do not enter a program name with the NEW command, VAX BASIC assigns the name NONAME by default. BAS is the default file type.

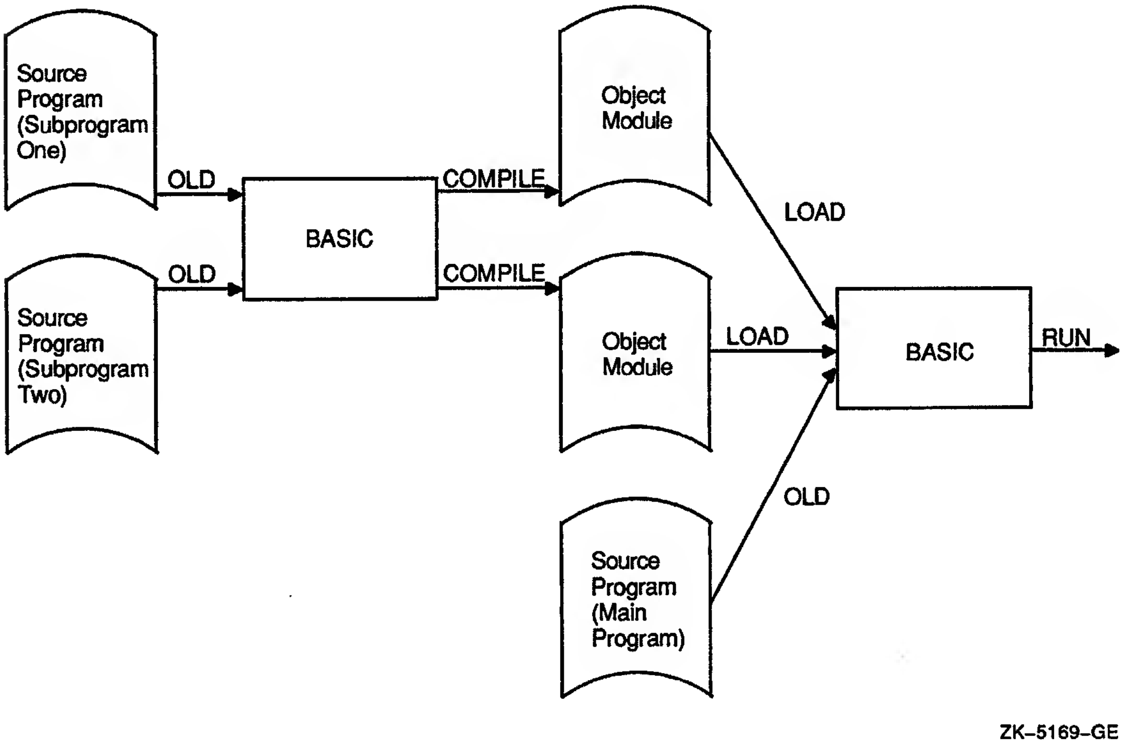
The RUNNH command compiles, links, and executes the program you create. To save this program, enter the SAVE command at the Ready prompt.

You can execute multiple-unit programs while in the BASIC environment. To execute multiple-unit programs, follow these steps:

1. Compile all subprograms to generate object modules
2. Use the OLD command to read the main program into memory
3. Use the LOAD command to read the subprogram object modules into memory
4. Type the RUN command

Figure 3–1 illustrates how to execute multiple-unit programs.

Figure 3–1: Running Multiple-Unit Programs



The following is an example of a program that contains multiple units:

Example

```
10      REM This program calls SUBPROGRAM SB1
20      PRINT "NOW IN MAIN PROGRAM"
30      CALL SB1
40      PRINT "BACK IN MAIN PROGRAM"
50      END

10      SUB SB1
20      PRINT "NOW IN SUBPROGRAM"
30      SUBEND
```

To execute this program in the BASIC environment, enter the following commands:

```
OLD SB1
Ready

COMPILE
Ready

OLD MAIN
Ready

LOAD SB1
Ready

RUN
```

Output

```
NOW IN MAIN PROGRAM
NOW IN SUBPROGRAM
BACK IN MAIN PROGRAM
Ready
```

If a STOP statement or CTRL/C is encountered in a module other than the currently compiled module, VAX BASIC signals "Compiled procedure is currently not active". At this point, you cannot use immediate mode statements.

When you run multiple-unit programs in the BASIC environment, only one module is currently compiled. Normally, the currently compiled program is the one you read into memory with the OLD command. However, if a source file contains more than one program module, the last one (the one closest to the end of the source file) is the currently compiled module. In the previous example, MAIN is the currently compiled module.

For more information on loading multiple object modules, see Section 3.4.

3.3 Immediate Mode

You do not have to write a complete program in order to use VAX BASIC. Many statements are executable in *immediate mode.*

Immediate mode statements are BASIC statements that are executed immediately after you press the RETURN key. Immediate mode statements cannot be preceded by a line number, space, or tab and can be used only if you are working directly in the environment.

In the following example, VAX BASIC interprets the first line as a comment because it begins with an exclamation point (!). VAX BASIC interprets the second line as part of a larger program because it begins with a line number. This line will not execute until a RUN command is specified. The third line does not begin with a line number, a space, or an exclamation point. Therefore, VAX BASIC treats the line as an immediate mode statement and immediately displays the specified text.

Example

```
!In the environment, this is a comment RET
10  PRINT 'This is an executable VAX BASIC statement' RET
PRINT 'THIS IS AN IMMEDIATE MODE STATEMENT' RET
```

Output

```
THIS IS AN IMMEDIATE MODE STATEMENT
Ready
```

The Ready prompt indicates that VAX BASIC is ready to receive compiler commands, immediate mode statements, or new program lines.

You can precede each executable statement with a backslash (\ ). You can also have more than one VAX BASIC statement on a line if you separate them with a backslash. However, programs with backslashes are often difficult to read.

Example

```
Ready

A = (54.37 / 1.25 ) \ B = ( 328.15^2) \ PRINT ( B / A )
 2475.69
```

Unless the compiler has executed a STOP statement, VAX BASIC compiles and executes each immediate mode statement as if it were a self-contained program.

Example

```
Ready
PRINT PI * 67.3
 211.421
```

Even if the current program has executed a STOP statement, you can still perform independent calculations. However, you should understand that after a stop, any immediate mode statement referencing program variables uses the values assigned in the program. Note that you cannot create new program variables after a STOP statement has been executed.

If the current program has not executed a STOP statement, each immediate mode line exists by itself, and any variables used by the statements on that line are temporary.

Example

```
Ready
A = 2^5 \ PRINT A
 32

READY

PRINT A
 0
```

The second PRINT statement causes VAX BASIC to display a zero because the compiler treats *A* as a new variable, and initializes it to zero.

You can use the IF, WHILE, UNTIL, UNLESS, and FOR statement modifiers in immediate mode statements. The following example shows how you can generate a table of square roots by using the immediate mode statement:

Example

```
Ready

PRINT I, SQR (I) FOR I = 1 TO 10
 1              1
 2              1.41421
 3              1.73205
 4              2
 5              2.23607
 6              2.44949
 7              2.64575
 8              2.82843
 9              3
 10             3.16228
Ready
```

Certain statements are invalid in immediate mode. In general, invalid statements are statements that require the allocation of new storage, or statements that make no sense in the context of a single line. If you try to execute such a statement, VAX BASIC signals the error "Illegal in immediate mode".

3.4 Debugging in Immediate Mode

To debug in immediate mode, you insert STOP statements in your program at the points where you wish to examine the values of variables. When VAX BASIC encounters a STOP statement, program execution is interrupted. At this point, you can use immediate mode statements to display the values of

variables or to assign them new values. After changing or examining data, you can use the CONTINUE command to resume program execution.

The following restrictions apply when you are debugging in immediate mode:

- You cannot continue execution if you have changed any program code; for example, you cannot create new variables after VAX BASIC has encountered a STOP statement. Neither can you use the CONTINUE command after you have inserted a STOP statement into your program in immediate mode. In both cases, you have changed program code and you must reexecute the program with the RUN command.
- You can debug only one module at a time; VAX BASIC lets you examine and change variables only in the current module (the most recently compiled module) of a multiple-unit program.

When you are debugging multiple program units in the environment, you should follow these guidelines:

- Use the OLD command to read in the source file for the module you want to debug. This source file becomes the current module, that is, the one available for immediate mode debugging.
- Use the LOAD command to read in the object files for the remaining program modules.

An object module is the file that results from compiling a source file; its format is an intermediate step between a source file and an executable image. The LOAD command removes any previously loaded object modules, whether or not the command specifies any object module files. Therefore, you must use a single LOAD command to specify all the object files you need. In addition, you must separate multiple object modules with plus signs.

The object files are not linked with the current program or executed until you issue the RUN command. Therefore, run-time errors in the loaded modules are not detected until you execute the program.

When you want to run a program, you can load all the object modules for that program and then execute the program with the RUN command. If you want to debug a program, you use the OLD command for the module you want to debug and then load the remaining program modules. The module to be debugged can be either a main program or a subprogram because, when you enter the RUN command, VAX BASIC transfers control to the main program, whether it is in object-module format or source-program format.

For information on using the VMS Debugger, see Chapter 5.

3.5 Compiler Commands

Compiling is the process of translating a source program to an object module. An object module is an intermediate step between source code and an executable image. It contains information that the linker uses to create an image.

You can compile, link, and execute your programs in the environment simply by typing the RUN command. This greatly reduces the number of steps you have to go through to develop VAX BASIC programs. When you are satisfied with a portion of code, you can simply run that program to examine whether or not it functions as expected. If you use the COMPILE command instead, you can eliminate all compile-time errors before you link and execute the program.

VAX BASIC has certain defaults that are in effect each time you enter the BASIC environment. Unless you explicitly override these defaults, they remain in effect until you leave the environment. You can see a listing of these defaults by typing the SHOW command when in the environment. The following example displays the standard BASIC environment defaults that are in effect when you enter the environment:

```
SHOW

VAX BASIC V3.4 Current Environment Status 22-JUN-1989 10:12:12.05
DEFAULT DATA TYPE INFORMATION:          LISTING FILE INFORMATION INCLUDES:
    Data type : REAL                       NO Source
    Real size : SINGLE                     NO Cross reference
    Integer size : LONG                       CDD Definitions
    Decimal size : (15,2)                     Environment
    Scale factor : 0                       NO Override of %NOLIST
    NO Round decimal numbers               NO Machine code
                                              Map
COMPILATION QUALIFIERS IN EFFECT:             INCLUDE files
       Object file
       Overflow check integers          FLAGGERS:
       Overflow check decimal numbers      NO Declining features
       Bounds checking                     NO BASIC PLUS 2 subset
    NO Syntax checking
       Lines
       Variant : 0                      DEBUG INFORMATION:
       Warnings                               Traceback records
       Informationals                      NO Debug symbol records
       Setup
       Object Libraries : NONE
Ready
```

You can override any of these defaults with qualifiers to the COMPILE or SET commands, or with the OPTION statement in your program. Table 3–1 lists and describes all the VAX BASIC compiler commands, including qualifiers to both the COMPILE and RUN commands. For more information on the OPTION statement, see the *VAX BASIC Reference Manual.*

Table 3–1: VAX BASIC Compiler Commands

Command	Description
! comment	Identifies a comment.
$ command	Starts a subprocess to execute the specified DCL command.
APPEND	Merges the specified program with the program currently in memory.
ASSIGN	Assigns a logical name to a complete file specification (the equivalence name).
COMPILE	Generates an object module (file type OBJ) from a VAX BASIC source program.
CONTINUE	Resumes execution after a STOP statement or a CTRL/C.
DELETE	Erases the specified line or lines from a VAX BASIC source program.
EDIT	Changes source text or calls a text editor.
EXIT	Returns to DCL command level.
HELP	Displays HELP text.
IDENTIFY	Causes VAX BASIC to print an identification header on the terminal.
LIST	Displays the current source program on the terminal.
LISTNH	Displays the current source program without header information.
LOAD	Loads an object module into memory.
LOCK	Specifies default values for compiler command qualifiers (identical to the SET command).
NEW	Clears memory for the creation of a new program and assigns a new program name.
OLD	Reads a specified VAX BASIC source program into memory.
RENAME	Changes the name of the program currently in memory.
REPLACE	Replaces a stored program with the program currently in memory.
RESEQUENCE	Supplies new line numbers for the program currently in memory.

(continued on next page)

Table 3–1 (Cont.): VAX BASIC Compiler Commands

Command	Description
RUN	Executes the program currently in memory, or a specified VAX BASIC source program. The program in memory can be: • A VAX BASIC source program placed in memory with the OLD command • One or more object modules placed in memory with the LOAD command • A combination of the first two
RUNNH	Identical to RUN but does not display header information.
SAVE	Creates a copy of the current source program on a specified device.
SCALE	Controls accumulated round-off errors for numeric operations.
SCRATCH	Erases the current program and any loaded object modules.
SEQUENCE	Generates line numbers for input text.
SET	Specifies default values for compiler command qualifiers.
SHOW	Displays the current default compiler qualifiers.
UNSAVE	Deletes a specified file.

The following sections describe these compiler commands. For more detailed information, see the *VAX BASIC Reference Manual.*

3.5.1 Entering Comments

VAX BASIC allows you to enter comments into the BASIC environment by specifying an exclamation point. Any text that follows the exclamation point (!) is treated as a comment. For example:

```
$ TYPE build_special.com
$ SET VERIFY
$ BASIC
!+
! Set the compilation unit options by uncommenting
! the appropriate ones
!-
!SET LIST
SET WORD
SET DEBUG
!+
! Get the source module.
!-
OLD SPECIAL
!+
! Compile it.
!-
COMPILE
!+
! All done.
!-
EXIT
```

3.5.2 Entering DCL Commands

You can enter a DCL command while in the environment by preceding it with a dollar sign ($). VAX BASIC passes the command to the DCL for execution. The program currently in memory does not change.

VAX BASIC starts a subprocess to execute the command, and the command executes in the context of that subprocess. This can sometimes produce unexpected results. For example, a $ SET DEFAULT command typed in the BASIC environment sets the default for the subprocess but not for the process in which VAX BASIC executes. The newly set default exists only until control returns to VAX BASIC.

3.5.3 The APPEND Command

The APPEND command merges a VAX BASIC source program with the program currently in memory. The program in memory must be a VAX BASIC source program that has been placed in memory with the OLD command and entered in the environment. The program must also contain at least one line number.

If both programs contain a line with the same number, the appended program line replaces the current program line.

If you type APPEND without specifying a file name, VAX BASIC prompts with:

```
Append file name--
```

You should respond with a file name. If you respond by typing the RETURN key, VAX BASIC searches for a file called NONAME with the default file type of BAS. If the compiler cannot find the file, it signals an error.

The APPEND command does not change the name of the program in memory.

3.5.4 The ASSIGN Command

The ASSIGN command equates a logical name to a complete file specification, a device, or another logical name.

If the logical name translates to a device name and will be used in place of a device name in a file specification, terminate the equivalence name with a colon.

This example uses the ASSIGN command to make the system HELP library available from within VAX BASIC:

```
Ready
ASSIGN SYS$HELP:HELPLIB HLP$LIBRARY
```

The ASSIGN command does not support search lists. To assign a logical name to a search list from within the environment, use the $ system-command to execute the DCL command ASSIGN with the /JOB qualifier. For example:

```
$ ASSIGN/JOB DUA0:[MR.X],DUA0:[MR.Y] TWO$DIRECTORIES:
```

3.5.5 The COMPILE Command

When you compile a program in the BASIC environment, there are three levels at which you can specify options for the compiler:

- You can accept the defaults of the BASIC environment as options
- You can specify options with qualifiers to the COMPILE or SET command
- You can specify options in the source program with the OPTION statement

The COMPILE command creates an object module from a source program in memory. You can control the compilation of your program with the COMPILE command and its qualifiers. These qualifiers duplicate many of the qualifiers available to the DCL command BASIC. You can abbreviate all COMPILE qualifiers to four letters. For example, you can compile a program currently in memory and specify the creation of a listing file:

```
COMPILE/LIST
```

The following two commands both specify that a listing file should be created. Note that the SET command sets a particular default until you leave the BASIC environment or until you specify a different default for that value, whereas the qualifiers to the COMPILE command set the defaults only for that particular compilation.

```
SET/LIST
```

```
COMPILE/LIST
```

If you do not specify any qualifiers with the SET command, VAX BASIC resets the defaults to the values that were in effect when you entered the BASIC environment.

The qualifiers to the COMPILE command are shown in the following list. Note that you can also use many of these qualifiers with the SET command to establish these compiler options. The qualifiers are described fully in the *VAX BASIC Reference Manual.*

- The **/[NO]ANSI_STANDARD** qualifier causes VAX BASIC to compile the program according to ANSI Minimal BASIC rules and to flag statements that do not conform to the ANSI Minimal BASIC standard. Note that the /ANALYSIS_DATA qualifier cannot be in effect when compiling with the /ANSI_STANDARD qualifier. The default is /NOANSI_STANDARD.
- The **/[NO]AUDIT** qualifier causes VAX BASIC to include a history entry in the Common Data Dictionary/Plus (CDD/Plus) database when a CDD/Plus definition is extracted. The default is /NOAUDIT.
- The **/[NO]BOUNDS_CHECK** qualifier causes VAX BASIC to perform range checks on array subscripts. That is, it checks that all array references are to addresses within the array boundaries. The default is /BOUNDS_CHECK=(BOUNDS,OVERFLOW).
- The **/BYTE** qualifier specifies that integers not explicitly typed with a data type keyword use 8 bits of storage, which lets you use integer values between –128 and 127. The default is /INTEGER_SIZE=LONG.

- The **/[NO]CROSS_REFERENCE[=[NO]KEYWORDS]** qualifier causes VAX BASIC to generate a cross-reference listing. If you specify KEYWORDS, VAX BASIC provides a cross-reference list of VAX BASIC keywords. If you specify /CROSS_REFERENCE, the default is /CROSS_REFERENCE=NOKEYWORDS. The default is /NOCROSS_REFERENCE.
- The **/[NO]DEBUG** qualifier provides the debugger with local symbol definitions for program variables, constants, line numbers, and labels. If you make changes to a program within the environment, you must first save or replace the program before attempting to compile the program with the /DEBUG qualifier; otherwise, VAX BASIC signals the error "Unsaved changes, no source line debugging available".

  The default is /DEBUG=(TRACEBACK,NOSYMBOLS).
- The **/DECIMAL_SIZE** qualifier specifies the default size and precision for all DECIMAL data not explicitly assigned size and precision in the program. You specify the total number of digits (d) and the number of digits to the right of the decimal point (s). VAX BASIC signals the error "Decimal error or overflow" (ERR=181) when DECIMAL values are outside the range specified with this qualifier. The default is /DECIMAL_SIZE=(15,2).
- The **/DOUBLE** qualifier specifies that floating-point data use 64 bits of storage in D_float format, which lets you use floating-point values in the range $2.9 * 10^{-39}$ to $1.7 * 10^{38}$ and with up to 16 digits of precision. The default is /REAL_SIZE=SINGLE.
- The **/[NO]FLAG[=([NO]BP2COMPATIBILITY,[NO]DECLINING)]** qualifier causes VAX BASIC to issue informational messages when your program includes statements that are not compatible with the functionality you specify. You can specify a flag for BASIC-PLUS-2, and declining VAX BASIC language features. The default is /NOFLAG.
- The **/GFLOAT** qualifier specifies that floating-point data use 64 bits of storage in G_float format, which lets you use floating-point values in the range $5.6 * 10^{-308}$ to $9.0 * 10^{309}$ and with up to 15 digits of precision. The default is /REAL_SIZE=SINGLE.
- The **/HFLOAT** qualifier specifies that floating-point data use 128 bits of storage in H_float format, which lets you use floating-point values in the range $8.4 * 10^{-4933}$ to $5.9 * 10^{4933}$ and with up to 33 digits of precision. The default is /REAL_SIZE=SINGLE.
- The **/[NO]LINES** qualifier enables the executing program to report the line number of statements causing errors and to use the RESUME statement without specifying a line number. The default is /LINES.

- The /[NO]LIST qualifier creates a program listing with a default file type of LIS. The default is /NOLIST.
- The **/LONG** qualifier specifies that untyped integers use 32 bits of storage, which lets you use integer values between –2147483648 and 2147483647. The default is /INTEGER_SIZE=LONG.
- The /[NO]**MACHINE_CODE** qualifier includes the compiler-generated assembly code listing. The default is /NOMACHINE_CODE.
- The /[NO]**OBJECT** qualifier generates a linkable object module. This object module has the same file name as the VAX BASIC source program and a default file type of OBJ. The default is /OBJECT.
- The /[NO]**OVERFLOW[=([NO]INTEGER,[NO]DECIMAL)]** qualifier enables the detection of arithmetic overflow on integer or packed decimal data. If you do not supply a value, OVERFLOW affects both data types. The default is /OVERFLOW=(INTEGER,DECIMAL).
- The /[NO]**ROUND** qualifier specifies whether VAX BASIC rounds or truncates packed decimal numbers. The default is /NOROUND.
- The /[NO]**SETUP** qualifier causes VAX BASIC to optimize the executable image by omitting certain calls to the Run-Time Library at the start and end of each program unit. Note that variables are not initialized when /NOSETUP is in effect. The default is /SETUP.
- The /[NO]**SHOW** qualifier allows you to specify what VAX BASIC should include in the listing file. For a list of items you can include in the listing file, see the *VAX BASIC Reference Manual*. The default is /SHOW.
- The /**SINGLE** qualifier specifies that floating-point data use 32 bits of storage, which lets you use floating-point values in the range $2.9 * 10^{-39}$ to $1.7 * 10^{38}$ and with up to 6 digits of precision. The default is /REAL_SIZE=SINGLE.
- The /[NO]**SYNTAX_CHECK** qualifier enables line-by-line syntax checking. Because VAX BASIC automatically performs syntax checking when you compile a program, you normally use /SYNTAX_CHECK with the SET command to enable line-by-line syntax checking while you are typing program lines. The default is /NOSYNTAX_CHECK.
- The /[NO]**TRACEBACK** qualifier provides line numbers for the debugger and error reporter so they can translate virtual addresses into source program module names and line numbers. The default is /TRACEBACK.

- The **/TYPE_DEFAULT** qualifier allows you to specify the default data type for all data not explicitly typed in your program. See the *VAX BASIC Reference Manual* for a list of data types you can include. The default is /TYPE_DEFAULT=REAL.
- The **/VARIANT=value** qualifier provides a value to be tested in conditional compilations. The default is /VARIANT=0.
- The **/[NO]WARNINGS[=[NO]WARNINGS,[NO]INFORMATIONALS]** qualifier tells VAX BASIC whether to display warning or informational error messages. /NOWARNINGS means that VAX BASIC does not display any informational or warning errors. The default is /WARNINGS=WARNINGS,INFORMATIONALS.
- The **/WORD** qualifier specifies that all integer data not explicitly typed use 16 bits of storage, which lets you use integer values in the range –32768 to 32767. The default is /INTEGER_SIZE=LONG.

If you use these qualifiers with the COMPILE command, the BASIC environment default values remain the same, but your program is compiled using the specified defaults. When you use these qualifiers with the SET command, you set the defaults for the period you are within the BASIC environment. You can also set compiler options from inside the source program by using the OPTION statement. See the *VAX BASIC Reference Manual* for more information on the OPTION statement.

If you specify the /DIAGNOSTICS qualifier or the /ANALYSIS_DATA qualifier with the BASIC command to enter the VAX BASIC environment, then make changes to a program and attempt to compile the program before saving or replacing it, VAX BASIC signals the error "Unsaved changes, no diagnostics file produced" or "Unsaved changes, no analysis file produced". You must save or replace the program before you compile it to generate a diagnostics or data analysis file.

3.5.6 The CONTINUE Command

The CONTINUE command resumes program execution after VAX BASIC encounters a STOP statement or a CTRL/C. After a STOP statement or a CTRL/C is encountered in the BASIC environment, you can enter immediate mode statements to display or change program variables. Then, type CONTINUE to resume execution with the new values.

3.5.7 The DELETE Command

The DELETE command removes a specified line or lines from the source program currently in memory. If you separate line numbers with commas, VAX BASIC deletes only the specified program lines. If you separate line numbers with a hyphen (–), VAX BASIC deletes the specified program lines and all program lines between them. For example:

DELETE 10	Removes line 10 from the program
DELETE 50, 100	Removes lines 50 and 100 from the program
DELETE 50, 100-190	Removes line 50 and lines 100 through 190 from the program

If you do not specify a line number, the DELETE command is ignored.

3.5.8 The EDIT Command

The EDIT command replaces text in the current program with text you supply in the command. If you type EDIT with no argument, VAX BASIC invokes a text editor and reads the current program into the editor's buffer.

Table 3–2 shows examples of editing in line mode.

Table 3–2: Examples of Editing in Line Mode

EDIT 100 /LEFT$/RIGHT$/	Replaces the first occurrence of LEFT$ with RIGHT$ on line 100.
EDIT	Invokes the default editor and reads the current program into the editor's buffer.
EDIT 2000	Lists line 2000 (line 2000 becomes the default EDIT line).
EDIT 30 /LEFT$/RIGHT$/,3	Starts the search on the third text line of program line 30 and replaces the first occurrence of LEFT$ with RIGHT$.
EDIT 300/LEFT$//2	Removes the second occurrence of the string LEFT$ from line 300. Note that you must specify delimiters around the null replacement string. Otherwise, the EDIT command would replace the first occurrence of LEFT$ with 2.

Entering EDIT with no argument causes VAX BASIC to save your program temporarily in a file called BASEDITMP.BAS. The editor is then invoked and you can edit the program in the usual manner. Exiting from the editor

causes the changed program to become the new current program. VAX BASIC then displays the Ready prompt. Note that VAX BASIC deletes all versions of BASEDITMP.BAS when control returns from the editor.

VAX BASIC supports the following callable text editors:

- VAX EDT
- VAX Text Processing Utility (VAXTPU)
- VAX Language-Sensitive Editor (LSE)

The default editor for VAX BASIC is EDT. In DCL, you or your system manager can override this default by defining the logical name BASIC$EDIT. To find out if a system assignment exists, enter the following DCL command:

```
$ SHOW LOGICAL BASIC$EDIT
```

The name you assign to BASIC$EDIT must be in the form *nnn*$EDIT, where the characters *nnn* represent the acronym for the editor. For example, you can assign LSE to be the default editor with the following command:

```
$ ASSIGN "LSE$EDIT" BASIC$EDIT
```

If the translation of BASIC$EDIT does not conform to *nnn*$EDIT, VAX BASIC creates a temporary file containing your source code and spawns a subprocess. VAX BASIC passes the translation of BASIC$EDIT to the subprocess.

3.5.9 The EXIT Command

The EXIT command clears memory and returns control to DCL command level. If you modify a program and issue the EXIT command before you copy it to disk with the SAVE or REPLACE command, VAX BASIC signals "Unsaved change has been made, CTRL/Z or EXIT to exit". This message warns you that any changes will be lost if you do not save the program. You can then store the program or retype the EXIT command (or press CTRL/Z) to exit from VAX BASIC.

3.5.10 The HELP Command

The HELP command lets you display the contents of the VAX BASIC HELP library on the terminal. Entering HELP causes the HELP facility to display a long list of VAX BASIC commands and language topics for which there is help available. You are then prompted to name a command or topic with the following prompt:

```
Topic?
```

To obtain help on the environment commands, you can type COMMANDS at the Topic? prompt. A list of commands is displayed on your terminal followed by the prompt COMMANDS Subtopic?. When you type a command name in response to this prompt, the HELP facility displays the following:

- An explanation of the command's purpose
- An example of its use
- A list of any further subtopics available

You can also display help text for VAX BASIC errors. The help texts for the VAX BASIC error messages are grouped under two categories: compile-time errors and run-time errors. A run-time error refers to any error that occurs during program execution. All other errors are referred to as compile-time errors. Typing HELP RUN displays a list of the 3- to 9-character error mnemonics for the VAX BASIC list of run-time errors, and typing HELP COMPILE displays a list of the 3- to 9-character compile-time error mnemonics.

For example, suppose your program invokes a user-defined DEF function with a null argument. This causes VAX BASIC to signal actual argument must be specified. The actual error message looks like this:

```
%BASIC-E-ACTARGMUS, actual argument must be specified
```

You display the help text by typing:

```
HELP COMPILE ACTARGMUS
```

The following text is then displayed on your screen.

```
ACTARGMUS

     ERROR - A DEF function reference contains a null argument,  for
     example FNA(1,,2). Specify all arguments when referencing a DEF
     function.
```

You can access run-time errors with either the mnemonic or the error number. You specify the error number with the letters "ERR" followed by the error number. For example, you can display the HELP text for the end-of-file error by using the mnemonic as shown:

```
HELP RUN ENDFILDEV
```

If you know only the error number, type:

```
HELP RUN ERR11
```

VAX BASIC displays the appropriate mnemonic for that error.

3.5.11 The IDENTIFY Command

The IDENTIFY command prints a header containing the VAX BASIC compiler name and version number. For example:

```
IDENTIFY

VAX BASIC V3.4

Ready
```

3.5.12 The LIST and LISTNH Commands

The LIST and LISTNH commands display a specified line or lines. If you type LIST or LISTNH without specifying line numbers, VAX BASIC displays a copy of the source program currently in memory, in ascending line number order.

The LIST command prints a header displaying the program name and the current time and date before displaying the specified lines. The LISTNH command suppresses the header information and prints the specified lines only. For example:

LIST 10	Displays header information, then displays line 10.
LISTNH 50, 100	Displays lines 50 and 100.
LIST 50, 90, 100-190	Displays header information, then displays lines 50, 90, and 100 through 190.

3.5.13 The LOAD Command

The LOAD command makes an object module available for execution with the RUN command. You can load only object files created by VAX BASIC.

The LOAD command accepts multiple device, directory, and file specifications. The LOAD command deletes all previously loaded object files; therefore, to load several files at the same time, you must separate the file specifications with plus signs. Multiple file specifications separated with commas cause each file to be loaded separately, thereby deleting the previously loaded file.

If you do not specify any file specification, the LOAD command erases any previously loaded object files.

```
LOAD OLD1 + OLD2 + OLD3

Ready

RUN
```

The previous example loads the files OLD1.OBJ, OLD2.OBJ, and OLD3.OBJ for execution. These object files are not linked with the current program or executed until you issue the RUN command. Therefore, run-time errors in the loaded modules are not detected until you execute the program.

Each device and directory specification applies to all following file specifications until you specify a new directory or device. For example:

```
LOAD DUA1:[SMITH]PROG3+[JONES]PROG4+DUA2:PROG5
```

This command loads three object files:

- PROG3 from the directory SMITH on the device DUA1:
- PROG4 from the directory JONES on DUA1:
- PROG5 from the directory JONES on DUA2:

3.5.14 The LOCK Command

The LOCK command changes default values for COMPILE command qualifiers. It is equivalent to the SET command. The following command specifies that all subsequent compilations use double-precision, floating-point numbers as the default. You can use any valid COMPILE command qualifier as an argument to LOCK.

```
LOCK /DOUBLE

Ready
```

3.5.15 The NEW Command

The NEW command clears the memory and assigns a name to a program to be entered. The following command assigns the name PROG1 to the program. You can then enter program lines.

```
NEW PROG1
```

If you do not specify a name, VAX BASIC issues the following prompt:

```
New file name--
```

You should respond with a name. If you press the RETURN key in response to the prompt, VAX BASIC assigns the name NONAME.

3.5.16 The OLD Command

The OLD command brings a previously created VAX BASIC source file into memory. The following command reads PROG1.BAS into memory:

```
OLD PROG1
```

If you do not specify a file name, VAX BASIC issues the prompt:

```
Old file name--
```

You should respond with a file name. If you do not specify a file type, VAX BASIC reads a file with the specified file name and the default file type. If you press the RETURN key in response to the prompt, VAX BASIC searches for a file with the default file name and default file type: NONAME.BAS.

3.5.17 The RENAME Command

The RENAME command assigns a new name to the program currently in memory. For example, the following command sequence brings a program named PROG1 into memory and changes its name and directory:

```
OLD [KELLY]PROG1
Ready

RENAME [MCKAY.BASIC]PROG2
```

The name of the program is changed to PROG2. If you perform a REPLACE operation, PROG2 is copied to the subdirectory [MCKAY.BASIC] instead of [KELLY]. The remaining portion of the specification is unchanged. If you do not specify a program name, VAX BASIC renames the current program NONAME.

3.5.18 The REPLACE Command

The REPLACE command writes the program in memory to a specified device. The REPLACE command always writes a copy of the current program back to disk. It replaces it using the file specification specified in the last OLD command. Part or all of this file specification can be overwritten with the RENAME command; whatever parts are not specifically changed remain the same. RENAME is similar to SAVE except that while SAVE copies the current program to the default directory, REPLACE copies the current program to the location specified in the program's current file specification.

After execution of a REPLACE command, VAX BASIC issues an informational message confirming the file specification.

3.5.19 The RESEQUENCE Command

The RESEQUENCE command allows you to resequence the line numbers of the program currently in memory. VAX BASIC also changes all references to the old line numbers so they reference the new line numbers. You can specify a starting line number and a value by which to increase each subsequent line number. The following command resequences the line numbers from 10 to 10000, making the first line number 100 and increasing each subsequent line number by 20:

```
RESEQUENCE 10-10000 100 STEP 20
```

The RESEQUENCE command is not allowed on programs without line numbers.

3.5.20 The RUN and RUNNH Commands

The RUN command executes a program. This program can be any one of the following:

- The current program
- One or more object modules placed in memory with the LOAD command
- A combination of the first two
- A specified VAX BASIC source program

If you do not supply an alternative file specification, VAX BASIC executes the program in memory.

```
Ready

OLD
Old file name--PROG1
Ready

RUN
```

The RUN command compiles, links, and executes PROG1. It prints a header displaying the program name and the current date and time. To execute a program without displaying this header, type RUNNH.

The RUN command does not create an object module file or a list file. It uses whatever qualifiers have been set. The following qualifiers are always in effect for the RUN and RUNNH commands:

- NOCROSS
- NODEBUG
- NOLIST
- NOMACHINE
- NOOBJECT
- SETUP

The RUN command can invoke only VAX BASIC procedures and other procedures that reside in shareable image libraries. See Chapter 22 for more information on creating shareable images.

3.5.21 The SAVE Command

The SAVE command copies a VAX BASIC source program from memory to a file. You can specify a storage device, a file name, and a file type in the SAVE file-spec. For example, if you type the following program, a SAVE command causes VAX BASIC to arrange the program in ascending line number order and copy it to a file on MTA1:, in the current default directory with file name TEST and the default file type of BAS.

Example

```
10 REM THIS IS A TEST
30 PRINT "THIS IS A TEST"
SAVE MTA1:TEST.BBB
```

VAX BASIC saves the program on magnetic tape MTA1: in the current default directory with a file name of TEST and a file type of BBB. If the program in memory has no name and you issue the SAVE command with no argument, VAX BASIC copies the program to a file named NONAME with the default file type in your current default device and directory. Note that if you perform a RENAME operation, before you issue the SAVE command followed by no argument, VAX BASIC still copies the program to the current default directory.

3.5.22 The SCALE Command

The SCALE command can overcome accumulated round-off errors by multiplying double-precision, floating-point values by 10 raised to the specified scale factor before storing them.

3.5.23 The SCRATCH Command

The SCRATCH command clears memory by doing one of the following:

- Resetting the program name to NONAME
- Removing any object files previously loaded with the LOAD command
- Removing the source file currently in memory

3.5.24 The SEQUENCE Command

The SEQUENCE command automatically generates line numbers for input text. After a SEQUENCE command, VAX BASIC prompts with a line number and prompts again after each source line you enter. If you press CTRL/Z (either in response to the line number prompt or at the end of a program line), VAX BASIC stops prompting and you can enter source text in the normal way. If you specify a starting line number that already contains a statement, VAX BASIC signals "Attempt to sequence over existing statement" and returns to normal input mode.

Note that the SEQUENCE command is not allowed on programs without line numbers.

3.5.25 The SET Command

The SET command specifies defaults for compiler command qualifiers. For example:

```
SET /SINGLE
```

```
Ready
```

This command makes /SINGLE the default for the COMPILE or RUN command, thereby making SINGLE the default data type for all untyped values. Typing SET with no arguments resets the defaults to their state when you entered into the BASIC environment.

For a full list of options, see the COMPILE command.

3.5.26 The SHOW Command

The SHOW command displays the current default qualifiers and user libraries.

```
SHOW
```

```
VAX BASIC V3.4 Current Environment Status 22-JUN-1989 10:12:12.05
DEFAULT DATA TYPE INFORMATION:            LISTING FILE INFORMATION INCLUDES:
    Data type : REAL                           Source
    Real size : SINGLE                      NO Cross reference
    Integer size : LONG                        CDD Definitions
    Decimal size : (15,2)                      Environment
    Scale factor : 0                        NO Override of %NOLIST
    NO Round decimal numbers                NO Machine code
                                               Map
COMPILATION QUALIFIERS IN EFFECT:              INCLUDE files
       Object file
       Overflow check integers            FLAGGERS:
    NO Overflow check decimal numbers          Declining features
       Bounds checking                      NO BASIC PLUS 2 subset
    NO Syntax checking
       Lines
       Variant : 0                        DEBUG INFORMATION:
    NO Warnings                                Traceback records
    NO Informationals                       NO Debug symbol records
       Setup
       Object Libraries : NONE
Ready
```

This DEFAULT DATA TYPE INFORMATION display gives you the following information:

- The default data type is REAL.
- The default size for floating-point numbers is SINGLE, the default size for integers is LONG, and the default size for packed decimal numbers is (15,2).
- There is no scale factor in effect.
- Packed decimal numbers are truncated rather than rounded.

The LISTING FILE INFORMATION display tells you which parts of the program listing are included if you create a compilation listing:

- The source program is listed.
- No cross-reference information is listed.
- CDD definitions are displayed as RECORD statements.
- The qualifiers in effect when the program was compiled are listed. This means that the program listing contains the equivalent of this SHOW command.
- The %NOLIST compiler directive is not overridden.
- No compiler-generated machine code is listed.
- An allocation map is listed. This contains the sizes and offsets of any variables.
- Files accessed with the %INCLUDE directive are listed.

The COMPILATION QUALIFIERS IN EFFECT section gives you the following information:

- An object file is produced.
- Overflow checking for integers is enabled.
- Overflow checking for packed decimal numbers is disabled.
- Bounds checking is enabled.
- Line-by-line syntax checking is disabled.
- Line number information is included in the object file.
- The VARIANT value is zero.
- No warning or informational error messages are displayed.
- VAX BASIC performs normal initialization calls at run time (SETUP).
- No user-supplied object module libraries are searched.

The FLAGGERS section gives you the following information:

- Declining features are reported.
- BP2 compatibility issues are not reported.

The DEBUG INFORMATION section gives you the following information:

- Traceback information is included in the object module.
- No debug records are included in the object module. This means you cannot access program symbols with the VMS Debugger.

See Chapter 22 for more information about user libraries.

3.5.27 The UNSAVE Command

The UNSAVE command deletes the specified version of a file from disk. If you do not specify a file, UNSAVE deletes the disk file associated with the program currently in memory. If you do not specify a version number, UNSAVE deletes the newest version. For example:

```
OLD PROG1
Ready
UNSAVE
Ready
```

The OLD command copies a program named PROG1.BAS from disk to memory. The UNSAVE command deletes the program from disk.

You can delete a VAX BASIC source program other than the one in memory by specifying the program name. The following command deletes the most recent version of the file PROG2.BAS:

```
UNSAVE PROG2
```

To delete a file other than a source program, specify the file name and file type. The following command deletes the newest version of the object module generated from the compilation of PROG2:

```
UNSAVE PROG2.OBJ
```

Chapter 4

Developing VAX BASIC Programs at DCL Command Level

The process of developing a VAX BASIC program involves four steps: creating, compiling, linking, and running. You accomplish each of these steps using DCL commands. This chapter describes how to create, compile, link, and run a VAX BASIC program.

4.1 Creating a VAX BASIC Program

To create and modify a VAX BASIC program, you must invoke a text editor. VMS provides you with two text editors: VAX EDT (EDT) and the VAX Text Processing Utility (VAXTPU). You may also have other editors that are supported on your system, such as the VAX Language-Sensitive Editor (LSE). The following sections describe briefly how to use both VAX EDT and VAXTPU.

4.1.1 Using VAX EDT

EDT is an interactive, general-purpose text editor that offers three editing modes: keypad, nokeypad, and line. Both keypad and nokeypad modes are screen editors. Keypad mode uses the numeric keypad that appears to the right of your main keyboard. With nokeypad mode, you enter commands on a command line, which EDT processes when you press RETURN. Line mode focuses on the line as the basic unit of text. The appearance of a line mode asterisk prompt (*) indicates that you can enter a line mode command. When you begin your editing session, editing in line mode is the default. Unlike line mode, keypad mode and nokeypad mode continuously display the contents of the file on your screen.

The following command line invokes the EDT editor and creates the file, PROG_1.BAS:

```
$ EDIT/EDT PROG_1.BAS
```

To change from line mode to keypad mode, enter the CHANGE command at the asterisk prompt. To return to line mode from keypad mode, press CTRL/Z. To change from line mode to nokeypad mode, enter the SET NOKEYPAD command and then enter the CHANGE command.

If you are in the middle of an editing session and your system fails, you can recover your edits by reentering the EDIT command followed by the /RECOVER qualifier. EDT re-creates your last editing session on your screen up to the point where it was interrupted. It uses the contents of a journal file that is maintained during the editing session.

EDT provides an online HELP facility that you can access during an editing session. In line mode, you can enter the HELP command. EDT displays general information on EDT as well as detailed information on both line mode editing and nokeypad mode editing. In keypad mode, you can press the HELP key or the PF2 key. EDT displays a keypad diagram on your terminal screen, and a list of keypad editing keys. For help on a specific keypad function, press the key you want help on.

For details on how to use the EDT editor, see the *VAX EDT Reference Manual*.

4.1.2 Using VAXTPU

The VAX Text Processing Utility (VAXTPU) is a high-performance, programmable editor. With VAXTPU, you can use one of two editing interfaces to edit your VAX BASIC programs: the Extensible VAX Editor (EVE) and the VAXTPU EDT Keypad Emulator. You can also create your own interfaces. The following sections briefly describe how to use the EVE interface and the EDT Keypad Emulator interface.

4.1.2.1 The EVE Interface

The EVE editor is efficient and easy to use. You can execute common editing functions by using the EVE keypad, or execute more advanced functions by entering commands on the EVE command line. The following command line invokes the EVE editor and creates the file PROG_1.BAS:

```
$ EDIT/TPU PROG_1.BAS
```

You can define a global symbol for the EDIT/TPU command by placing a symbol definition in your LOGIN.COM file. For more information on defining global symbols, see Chapter 2.

Like EDT, VAXTPU provides you with an online HELP facility that you can access during your editing session. It also provides you with a journal facility. Unlike EDT, VAXTPU provides you with multiple windows. This feature allows you to view two files on your screen at the same time. VAXTPU also provides you with other advanced features.

For more information on using the features of EVE, see the *VAX Text Processing Utility Manual.*

4.1.2.2 The EDT Keypad Emulator Interface

The EDT Keypad Emulator interface provides all the functions associated with EDT and uses the same keys to perform each function. To access the EDT Keypad Emulator, enter the following command line:

```
$  EDIT/TPU/SECTION=EDTSECINI.GBL
```

To minimize the number of characters you must enter each time you invoke the EDT Keypad Emulator, you can define a global symbol for the command line and place it in your LOGIN.COM file. See Chapter 2 for more information on defining global symbols.

For details on how to use the EDT Keypad Emulator, see the *VAXTPU EDT Keypad Emulator Quick Reference Guide.*

4.2 Compiling a VAX BASIC Program

The primary functions of the VAX BASIC compiler are to:

- Detect errors in your source program
- Generate any appropriate error messages
- Generate machine language instructions from the source statements
- Group these language instructions into an object module for the linker

To invoke the VAX BASIC compiler, you use the DCL command BASIC. With the BASIC command, you can specify command qualifiers. The next two sections discuss in detail the BASIC command as well as all of the command qualifiers available with the command.

4.2.1 The BASIC Command

When you compile your source program, use the BASIC command, which has the form:

BASIC [/qualifier...][file-spec [/qualifier...]],...

/qualifier
The name of a qualifier that indicates a specific action to be performed by the compiler on all files or specific files listed. When a qualifier appears directly after the BASIC command, it affects all files listed.

file-spec
Indicates the name of the input source file that contains the program or module to be compiled. You are not required to specify a file extension; the VAX BASIC compiler assumes the file to be of the default file type, BAS.

If you enter the BASIC command with no parameters, you will enter the BASIC environment. For more information on the BASIC environment, see Chapter 3.

Most of the command qualifiers to the BASIC command affect all files specified in the command line, no matter where the qualifiers are placed; these are called *global* qualifiers. However, the qualifiers /LISTING, /OBJECT, and /DIAGNOSTICS are *positional* qualifiers; that is, depending on their position in the command line, they can affect all or only some of the specified files. The rules for positional qualifiers are as follows:

- If the positional qualifier is located directly following the command name, it affects all the specified files.
- If the file specifications are separated by commas, then any positional qualifier directly following a file specification affects only that file.
- If the file specifications are separated by plus signs, then any positional qualifier directly following a list of file specifications affects only the resulting appended file.
- The rightmost qualifier overrides any conflicting qualifier previously specified in the command line.

The placement of these positional qualifiers causes VAX BASIC to produce or not produce listing files, object files, and diagnostics files. For example:

```
$ BASIC/LIST/OBJ PROG1/NOOBJ/DIAG,PROG2+PROG3/NOLIST
```

This command does the following:

- Compiles PROG1 and produces a listing file called PROG1.LIS

- Produces no object file for PROG1
- Produces a diagnostics file for PROG1 called PROG1.DIA
- Appends PROG2 and PROG3 for compilation, producing a temporary source file called PROG2
- Compiles the new PROG2 and produces an object file called PROG2.OBJ
- Produces no listing file for the new PROG2

Because VAX BASIC appends source files that are separated by plus signs, you should make sure that these files contain line numbers. VAX BASIC does not allow you to append programs without line numbers. You must also make sure that these files do not contain duplicate line numbers. If there are duplicate line numbers, VAX BASIC replaces the first instance of that numbered line with the second.

You should be careful when using positional qualifiers inside a list of files separated with plus signs, because a positional qualifier specified for a single file affects all the files in that list. In the following example, the /NOOBJ positional qualifier appears to apply only to PROG2. However, since VAX BASIC appends PROG1, PROG2, and PROG3 to form one file called PROG1, the /NOOBJ qualifier applies to the new PROG1 and VAX BASIC does not produce an object module.

```
$ BASIC PROG1+PROG2/NOOBJ+PROG3
```

4.2.2 BASIC Command Qualifiers

The following list represents all the command qualifiers and their defaults available with the DCL command BASIC. The SINGLE, DOUBLE, WORD, and LONG qualifiers are supported for compatibility with older versions of VAX BASIC. However, DIGITAL recommends that you use the /TYPE_DEFAULT, /INTEGER_SIZE, /REAL_SIZE, and /DECIMAL_SIZE qualifiers to set the default data type and size. A description of each qualifier follows the list.

Command Qualifier	Default
/[NO]ANALYSIS_DATA [= file-spec]	/NOANALYSIS_DATA
/[NO]ANSI_STANDARD	/NOANSI_STANDARD
/[NO]AUDIT [= text-entry]	/NOAUDIT
/[NO]CHECK [= (check-clause,...)]	/CHECK=(BOUNDS,OVERFLOW)
/[NO]CROSS_REF [= [NO]KEYWORDS]	/NOCROSS_REF
/[NO]DEBUG [= (debug-clause,...)]	/DEBUG=(TRACEBACK,NOSYMBOLS)
/DECIMAL_SIZE = (d,s)	/DECIMAL_SIZE=(15,2)

/[NO]DEPENDENCY_DATA	/NODEPENDENCY_DATA
/[NO]DESIGN	/NODESIGN
/[NO]DIAGNOSTICS [= file-spec]	/NODIAGNOSTICS
/DOUBLE	
/[NO]FLAG [= (flag-clause,...)]	/FLAG = (NODECLINING, NOBP2COMPATIBILITY)
/INTEGER_SIZE = data-type	/INTEGER_SIZE = LONG
/[NO]LINES	/LINES
/[NO]LISTING [= file-spec]	/NOLISTING (from terminal) /LISTING (batch)
/LONG	
/[NO]MACHINE_CODE	/NOMACHINE_CODE
/[NO]OBJECT [= file-spec]	/OBJECT
/[NO]OLD_VERSION=CDD_ARRAYS	/NOOLD_VERSION
/REAL_SIZE = data-type	/REAL_SIZE = SINGLE
/[NO]ROUND_DECIMAL	/NOROUND_DECIMAL
/SCALE = n	/SCALE = 0
/[NO]SHOW [= (show-item,...)]	/SHOW
/SINGLE	
/[NO]SYNTAX_CHECK	/NOSYNTAX_CHECK
/TYPE_DEFAULT = default-clause	/TYPE_DEFAULT = REAL
/VARIANT = int-const	/VARIANT = 0
/[NO]WARNINGS [= (warn-clause,...)]	/WARNINGS = (INFORMATIONALS, WARNINGS)
/WORD	

/[NO]ANALYSIS_DATA [= file-spec]
If the VAX Source Code Analyzer (SCA) is installed on your system, you can use the /ANALYSIS_DATA qualifier to create a file containing data analysis information. The file generated by the /ANALYSIS_DATA qualifier has a default file type of .ANA. You load .ANA files into an SCA library. SCA uses the ANA file to display cross-reference information and analyze source code.

Note that you cannot use the /ANALYSIS_DATA qualifier with the /ANSI_STANDARD qualifier. The default is /NOANALYSIS_DATA.

/[NO]ANSI_STANDARD
The /ANSI_STANDARD qualifier causes VAX BASIC to allow only statements valid for ANSI Minimal BASIC and to compile programs according to the ANSI Minimal BASIC rules.

The /NOANSI_STANDARD qualifier causes VAX BASIC to allow extensions and implementation-defined features.

Note that you cannot use the /ANSI_STANDARD qualifier with the /ANALYSIS_DATA qualifier. The default is /NOANSI_STANDARD. See the *VAX BASIC Reference Manual* for more information about ANSI standard BASIC.

/[NO]AUDIT = { str-lit | file-spec }

The /AUDIT qualifier causes VAX BASIC to include a history entry in CDD/Plus when extracting a CDD/Plus definition. You can specify either a string literal or a file specification with the /AUDIT qualifier. If you specify a string literal, VAX BASIC includes it as part of the history entry. If you specify a file specification, VAX BASIC includes up to the first 64 lines of the specified file. When you specify /AUDIT, VAX BASIC also includes the following information about the CDD/Plus record extraction in the history entry:

- The name of the program module making the extraction
- The time and date of the extraction
- A note that access was made by way of a VAX BASIC program
- A note that the access was an extraction
- The username and UIC of the process accessing CDD/Plus

The /NOAUDIT qualifier causes VAX BASIC not to include a history entry in CDD/Plus when extracting a CDD/Plus definition.

The default is /NOAUDIT.

/[NO]CHECK = { [NO]BOUNDS | [NO]OVERFLOW [=(INTEGER,DECIMAL)] | ALL | NONE }

The /CHECK qualifier causes VAX BASIC to test for arithmetic overflow and for array references outside array boundaries when the program executes. Specifying /CHECK=NOBOUNDS means that your program is smaller and runs faster. However, no error is signaled for an array reference outside the bounds of an array. This means that the program may get a memory management or access violation error at run time. Therefore, this option should be used only for programs that have been thoroughly debugged and whose execution time is critical. If you specify /CHECK=OVERFLOW, overflow checking is enabled for both integers and packed decimal numbers. Similarly, specifying /CHECK=NOOVERFLOW disables overflow checking for both types of numbers.

The /NOCHECK qualifier causes VAX BASIC to not test for arithmetic overflow and for array references outside array boundaries when the program executes.

/CHECK = ALL is the same as /CHECK = (BOUNDS,OVERFLOW).
/CHECK = NONE is the same as /NOCHECK.

The default is /CHECK = (BOUNDS,OVERFLOW).

/[NO]CROSS_REFERENCE [= [NO]KEYWORDS]
The /CROSS_REFERENCE qualifier causes VAX BASIC to generate a cross-reference listing. The cross-reference list shows program symbols, their class, and the program lines in which they are referenced. /CROSS_REFERENCE=KEYWORDS specifies that the cross-reference listing includes all references to VAX BASIC keywords. If you specify /CROSS_REFERENCE alone, the default is NOKEYWORDS. See Chapter 18 for more information on cross-reference listings.

The /NOCROSS_REFERENCE qualifier specifies that no cross-reference listing be produced.

The default is /NOCROSS_REFERENCE.

/[NO]DEBUG = { [NO]SYMBOLS | [NO]TRACEBACK | ALL | NONE }

The /DEBUG qualifier causes VAX BASIC to provide information for the VMS Debugger and the system run-time error traceback mechanism. Neither TRACEBACK nor SYMBOLS affects a program's executable code. For more information on debugging, see Chapter 5.

The /NODEBUG qualifier causes VAX BASIC to suppress information for the VMS Debugger and the system run-time error traceback mechanism.

/DEBUG = ALL is the same as /DEBUG = (TRACEBACK,SYMBOLS).
/DEBUG = NONE is the same as /NODEBUG.

The default is /DEBUG = (TRACEBACK,NOSYMBOLS).

/DECIMAL_SIZE = (d,s)
The /DECIMAL_SIZE qualifier lets you specify the default size for packed decimal data. You specify the total number of digits in the number and the number of digits to the right of the decimal point.

/DECIMAL_SIZE = (15,2) is the default. This default decimal size applies to all decimal variables for which the total number of digits and digits to the right of the decimal point are not explicitly declared. See the *VAX BASIC Reference Manual* for more information about packed decimal numbers.

/[NO]DEPENDENCY_DATA

If you have CDD/Plus Version 4.0 installed on your system, and if your current CDD$DEFAULT is a CDO-format dictionary, the /DEPENDENCY_DATA qualifier generates a compiled module entity in the CDD$DEFAULT for each compilation unit.

You must specify this qualifier if you want %INCLUDE %FROM %CDD and %REPORT %DEPENDENCY directives to establish dependency relationships.

/NODEPENDENCY_DATA is the default. No compiled module entity is generated in this case.

/[NO]DESIGN = $\left\{ \begin{array}{l} \textbf{COMMENTS} \\ \textbf{PLACEHOLDERS} \end{array} \right\}$

The /DESIGN qualifier enables Program Design Facility (PDF) processing. Therefore, if you specify the /DESIGN qualifier on the BASIC command line, PDF instructs the VAX BASIC compiler to recognize placeholders and comments as valid program elements.

In order to use all the capabilities of PDF, you must have the VAX Language-Sensitive Editor Version 3.0 or higher and the VAX Source Code Analyzer Version 2.0 or higher installed on your system. If you specify the /ANALYSIS_DATA qualifier, the VAX BASIC compiler includes information on comments and placeholders in the analysis data file.

To enable comment processing, you should specify /DESIGN=COMMENTS. To enable placeholder processing in place of VAX BASIC syntax, you should specify /DESIGN=PLACEHOLDERS.

If you specify the /DESIGN qualifier but do not select an option, the default is /DESIGN=(COMMENTS,PLACEHOLDERS); otherwise, the default is /NODESIGN.

/[NO]DIAGNOSTICS [= file-spec]

If you have the VAX Language-Sensitive Editor (LSE) installed on your system, you can use the /DIAGNOSTICS qualifier to create a diagnostics file containing compiler messages and diagnostic information. The diagnostics file is used by LSE to display diagnostic error messages and to position the cursor on the line and column where a source error exists.

If you do not supply a file specification with the /DIAGNOSTICS qualifier, the diagnostics file has the same name as its corresponding source file and a file type of DIA. All other file specification attributes depend on the placement of the qualifier in the command. See the VMS documentation set for more information.

The /NODIAGNOSTICS qualifier specifies that no diagnostics file will be created. The default is /NODIAGNOSTICS.

$$/[NO]FLAG = \left\{ \begin{array}{l} [NO]BP2COMPATIBILITY \\ [NO]DECLINING \\ ALL \\ NONE \end{array} \right\}$$

The /FLAG qualifier lets you specify whether VAX BASIC warns you about declining features and compatibility with PDP-11 BASIC-PLUS-2.

The /NOFLAG qualifier causes VAX BASIC to not warn you about declining features and compatibility with PDP-11 BASIC-PLUS-2.

/FLAG = ALL is the same as /FLAG = (BP2COMPATIBILITY,DECLINING).
/FLAG = NONE is the same as /NOFLAG.

The default is /FLAG = (NODECLINING,NOBP2COMPATIBILITY).

$$/INTEGER\_SIZE = \left\{ \begin{array}{l} BYTE \\ WORD \\ LONG \end{array} \right\}$$

The /INTEGER_SIZE qualifier lets you specify the default size for integer data.

The default is INTEGER_SIZE = LONG. The default integer size applies to all integer variables whose data type is not explicitly declared. See the *VAX BASIC Reference Manual* for more information about integer data types.

/[NO]LINES

The /LINES qualifier makes line number information available for the ERL function, the RESUME statement (with no target), and the VAX BASIC error reporter. If your program contains a RESUME statement with no target, or a reference to the error-handling function ERL, the compiler overrides NOLINES and signals "ERL overrides NOLINE" or "RESUME overrides NOLINE". Note that the VAX BASIC error reporting facility is separate from that of system traceback.

The /NOLINES qualifier causes line number information to be unavailable for the ERL function, the RESUME statement (with no target) and the VAX BASIC error reporter. Specifying /NOLINES makes your program run faster and reduces program size (this eliminates five bytes of code and four bytes of data for each program line number). However, specifying /NOLINES causes the following restrictions to be in effect:

- You cannot use RESUME without a line number
- You cannot use the ERL function
- No VAX BASIC line number is given in run-time error messages

Therefore, this option should be used only for programs that have been thoroughly debugged and whose execution time is critical.

The default is /LINES.

/[NO]LISTING

The /LISTING qualifier causes VAX BASIC to produce a source listing file.

To produce a listing file with an explicit file specification, you must use the /LISTING qualifier in the form /LISTING = file-spec. Otherwise, the listing file has the same name as its corresponding source file and a file type of LIS. All other file specification attributes depend on the placement of the qualifier in the command. See the *VMS DCL Concepts Manual* for more information. Note that the /LISTING qualifier only controls whether or not VAX BASIC produces a listing file. The /SHOW qualifier controls which parts of the listing are produced.

The /NOLISTING qualifier specifies that no source listing file be produced.

At a terminal, the default is /NOLISTING. In batch mode, the default is /LISTING.

/[NO]MACHINE_CODE

The /MACHINE_CODE qualifier specifies that the listing file includes the compiler-generated object code. If /LISTING is not specified, /MACHINE_CODE causes VAX BASIC to produce a listing file containing only the compiler-generated object code.

The /NOMACHINE_CODE qualifier specifies that the listing file not include compiler-generated object code.

The default is /NOMACHINE_CODE.

/[NO]OBJECT

The /OBJECT qualifier causes VAX BASIC to produce an object module, and optionally specifies its file name. By default, VAX BASIC generates object files as follows:

- If you specify one source file, VAX BASIC generates one object file.
- If you specify multiple source files separated by plus signs, VAX BASIC appends the files and generates one object file.
- If you specify multiple source files separated by commas, VAX BASIC compiles and generates a separate object file for each source file.
- You can use both plus signs and commas in the same command line to produce different combinations of appended and separated object files.

To produce an object file with an explicit file specification, you must use the /OBJECT qualifier in the form /OBJECT = file-spec. Otherwise, the object file has the same name as its corresponding source file and a file type of OBJ. All other file specification attributes depend on the placement of the qualifier in the command. See the *VMS DCL Concepts Manual* for more information.

The /NOOBJECT qualifier suppresses the creation of an object file. During the early stages of program development, you may find it helpful to suppress the production of object files until your source program compiles without errors.

The default is /OBJECT.

/[NO]OLD_VERSION=CDD_ARRAYS

The /OLD_VERSION=CDD_ARRAYS qualifier is provided for compatibility with previous versions of BASIC. When you use the /OLD_VERSION=CDD_ARRAYS qualifier, VAX BASIC changes the lower bound to zero and adjusts the upper bound of the array. For example, *Array 2:5* in CDD/Plus is translated by VAX BASIC to be an array with a lower bound of 0 and an upper bound of 3. VAX BASIC issues an informational message to confirm the array bounds.

The /NOOLD_VERSION qualifier causes VAX BASIC to extract an array from the Common Data Dictionary/Plus (CDD/Plus) with the bounds as specified in the data definition. For example, *Array 2:5* in CDD/Plus is translated by VAX BASIC to be an array with a lower bound of 2 and an upper bound of 5. VAX CDD/Plus assumes a default lower bound of 1, if none is specified. Therefore, if no lower bound is specified, VAX BASIC translates the CDD/Plus array to have a lower bound of 1. For example, *Array 5* in CDD/Plus is translated by VAX BASIC to be an array with a lower bound of 1 and an upper bound of 5.

The default is /NOOLD_VERSION.

/REAL_SIZE = { SINGLE | DOUBLE | GFLOAT | HFLOAT }

The /REAL_SIZE qualifier lets you specify the default size for floating-point data.

The default is /REAL_SIZE = SINGLE. The default floating-point size applies to all floating-point variables whose size is not explicitly declared.

See the *VAX BASIC Reference Manual* for more information on floating-point data types.

/[NO]ROUND_DECIMAL

The /ROUND qualifier specifies that VAX BASIC is to round packed decimal numbers rather than truncate them.

The /NOROUND qualifier causes VAX BASIC to truncate packed decimal numbers rather than round them.

The default is /NOROUND.

/SCALE = n

The /SCALE qualifier specifies a scale factor between zero and six, inclusive. The scale factor affects only double-precision numbers. SCALE helps to control accumulated round-off errors by multiplying floating-point values by 10 raised to the scale factor before storing them in variables. /SCALE is ignored for all but double-precision, floating-point numbers.

/SCALE is provided for compatibility with existing programs and with other implementations of VAX BASIC. DIGITAL recommends that you do not use this feature for new program development. Accumulated round-off errors can be better controlled with packed decimal numbers. See the *VAX BASIC Reference Manual* for more information on packed decimal numbers.

The default is /SCALE = 0.

$$
\textbf{/[NO]SHOW} = \left\{ \begin{array}{l} \textbf{[NO]CDD\_DEFINITIONS} \\ \textbf{[NO]ENVIRONMENT} \\ \textbf{[NO]INCLUDE} \\ \textbf{[NO]MAP} \\ \textbf{[NO]OVERRIDE} \\ \textbf{ALL} \\ \textbf{NONE} \end{array} \right\}
$$

The /SHOW qualifier determines which parts of the compilation listing are created. The /LISTING qualifier must be in effect for /SHOW to have any effect. The CDD_DEFINITIONS clause controls whether the translation of a CDD/Plus record is displayed in the listing. The ENVIRONMENT clause lets you display all defaults that were in effect when the program was compiled. This is the compilation listing equivalent of the SHOW command in the environment. The INCLUDE clause controls whether files accessed with the %INCLUDE directive are displayed in the listing. The MAP clause determines whether the listing contains an allocation map. The allocation map lists all program variables, their size, and their data type. The OVERRIDE clause helps you debug code by disabling the effect of the %NOLIST directive.

The /NOSHOW qualifier causes VAX BASIC to display only the source listing.

/SHOW = ALL is the same as /SHOW = (CDD_DEFINITIONS, ENVIRONMENT, INCLUDE, MAP, OVERRIDE). /SHOW = NONE is the same as /NOSHOW.

The default is /SHOW = (CDD_DEFINITIONS, ENVIRONMENT, INCLUDE, MAP, NOOVERRIDE).

/[NO]SYNTAX_CHECK
The /SYNTAX_CHECK qualifier causes VAX BASIC to perform line-by-line syntax checking. When syntax checking is enabled, VAX BASIC immediately checks the syntax of every text line as soon as you type a carriage return. When syntax checking is disabled, VAX BASIC does not perform syntax checking until you COMPILE or RUN the program.

The /NOSYNTAX_CHECK qualifier causes VAX BASIC to suppress line-by-line syntax checking.

The default is /NOSYNTAX_CHECK.

/TYPE_DEFAULT = $\left\{ \begin{array}{l} \textbf{INTEGER} \\ \textbf{REAL} \\ \textbf{DECIMAL} \\ \textbf{EXPLICIT} \end{array} \right\}$

The /TYPE_DEFAULT qualifier lets you specify the default data type for numeric variables.

Specifying EXPLICIT means that all program variables must be explicitly declared in DECLARE, EXTERNAL, COMMON, MAP, or DIM statements. Specifying INTEGER, REAL, or DECIMAL means only that variables and data which are not explicitly declared default to integer, real, or packed decimal. To specify the actual size of variables and data, use the INTEGER_SIZE, REAL_SIZE, and DECIMAL_SIZE qualifiers.

The default is /TYPE_DEFAULT = REAL.

/VARIANT = int-const
The /VARIANT qualifier lets you specify the value associated with the lexical function %VARIANT. See Chapter 18 in this manual for more information about VARIANT and the %VARIANT lexical function.

If /VARIANT is not specified, the default value is 0. If /VARIANT is specified without a value, the default is 1.

/[NO]WARNINGS = $\left\{ \begin{array}{l} \textbf{[NO]WARNINGS} \\ \textbf{[NO]INFORMATIONALS} \\ \textbf{ALL} \\ \textbf{NONE} \end{array} \right\}$

The /WARNINGS qualifier lets you specify whether VAX BASIC displays informational and warning error messages.

Specifying /WARNINGS=NOWARNINGS causes VAX BASIC to display informational errors but not warning errors. Specifying /WARNINGS=NOINFORMATIONALS causes VAX BASIC to display warning errors but not informational errors.

The /NOWARNINGS qualifier causes VAX BASIC to suppress any informational or warning errors.

/WARNINGS = ALL is the same as /WARNINGS = (INFORMATIONAL, WARNINGS). /WARNINGS = NONE is the same as /NOWARNINGS.

The default is /WARNINGS = (INFORMATIONAL,WARNINGS).

4.2.3 Compiler Listings

A compiler listing provides information that can help you debug your VAX BASIC program. To generate a listing file, specify the /LISTING qualifier when you compile your VAX BASIC program interactively. For example:

```
$ BASIC/LISTING prog-name
```

If the program is compiled as a batch job, the listing file is created by default; specify the /NOLISTING qualifier to suppress creation of the listing file. By default, the name of the listing file is the name of the source program followed by a file type of LIS. You can include a file specification with the /LISTING qualifier to override this default.

A compiler listing generated by the /LISTING qualifier has the following major sections:

- Source Program Listing

  The source program section contains the source code and line numbers generated by the compiler.
- Allocation Map

  The allocation map section contains summary information on program sections, variables, and arrays.
- Qualifier Summary

  The qualifier summary section lists the qualifiers used with the BASIC command and the compilation statistics.

Example 4–1 illustrates a compiler listing generated by the following command:

```
$ BASIC/LIST/CROSS_REFERENCE/MACHINE_CODE lister
```

Sections that follow the example describe each major section of the listing file. The numbered explanations in each section correspond to the callouts in Example 4–1.

Example 4–1: VAX BASIC Compiler Listing

```
  ❶                                  ❷                    ❸               ❹
LISTER$MAIN  Listing Tester  19-OCT-1989 11:27:36  VAX BASIC V3.4      Page  1
                                       ❺                   ❻
V1.5         Test            19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2
     ❼
     1        10     %TITLE "Listing Tester"
     2               %SBTTL "Test"
     3               %IDENT "V1.5"
     4
     5               !This program only shows the format of a listing
     6               !file.  It does no useful work.
     7
     8  ❽             %INCLUDE "MAPS.DEF"
     9  I1           ! MAPS definition file
    10  I1           MAP (SHARED)    STRING A = 16,   &
    11  I1                           LONG B,          &
    12  I1                           DOUBLE C,        &
    13  I1                           BYTE D
    14               DECLARE INTEGER INDEX
    15               DECLARE LONG CONSTANT TRUE = -1
    16               DECLARE SINGLE Q(5)
    17
    18               %IF %VARIANT = 2
    19    ❾           %THEN
    20    F1                  DECLARE DOUBLE Z(10)
    21               %END %IF
    22
    23
    24           First_loop:
    25               FOR INDEX = 0 TO 5
    26                 PRINT Q(INDEX)
    27               NEXT INDEX
    28
    29           Second_loop:
    30               WHILE TRUE
    31                 INDEX = INDEX + 1
    32                 EXIT Second_loop IF INDEX => 5
    33               NEXT
    34
    35       32767   END
    36
```

(continued on next page)

```
LISTER$MAIN  Listing Tester  19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   2
Cross Reference              19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2

User Identifier Cross Reference

Symbol                                     Datatype   Name Type

        +---------------------------------------------------+
        !    #  Defining reference                          !
        !    @  Destructive reference                       !
        !    P  Parameter reference                         !
        !    R  Redefining reference                        !
        +---------------------------------------------------+

A                                          STR=16     MAP            SHARED + 0
             10 #
B                                          LONG       MAP            SHARED + 16
             11 #
C                                          DOUBLE     MAP            SHARED + 20
             12 #
D                                          BYTE       MAP            SHARED + 28
             13 #
INDEX                                      LONG
             14 #            25              26            27            31 @   32
Q()                                        SINGLE
             16 #            26
TRUE                                       LONG       CONSTANT
             15 #            30

LISTER$MAIN      Listing Tester 19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   3
Cross Reference  Map            19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2

Map Cross Reference

Symbol                                     References

SHARED                                                MAP
             10 #
A                                          STR=16     MAP            SHARED + 0
             10 #
B                                          LONG       MAP            SHARED + 16
             11 #
C                                          DOUBLE     MAP            SHARED + 20
             12 #
```

(continued on next page)

```
D                                            BYTE       MAP              SHARED + 28
             13 #
     ⓬
Label Cross Reference

Symbol                                       References

FIRST_LOOP
             24 #

SECOND_LOOP
             29 #                   32

LISTER$MAIN  Listing Tester  19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   4
             ALLOCATION MAP  19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2


      ⓭
Allocation information for MAP SHARED

Name                                 Offset    Size      Type

A                                    0         16        Static string
B                                    16        4         Long
C                                    20        8         Double
D                                    28        1         Byte


      ⓮
Named constants

Name                                 Type           Value

TRUE                                 Long           -1


      ⓯
Allocation information for main program LISTER  Offset based on (R11)

Name                                 Offset    Size      Type

INDEX                                111       4         Long
Q                                    87        24        Single
   Dimensions : ( 0 TO 5 )
      ⓰
PROGRAM SECTIONS

    Name                         Bytes  Attributes
```

(continued on next page)

```
0 $PDATA                          112  PIC CON REL LCL   SHR NOEXE   RD NOWRT LONG
1 $CODE                           164  PIC CON REL LCL   SHR   EXE   RD NOWRT LONG
2 $ARRAY                            0  PIC CON REL LCL NOSHR NOEXE   RD   WRT LONG
3 $DESC                             0  PIC CON REL LCL NOSHR NOEXE   RD   WRT LONG
4 SHARED                           29  PIC OVR REL GBL   SHR NOEXE   RD   WRT LONG
      17
EXTERNAL REFERENCES

OTS$LINKAGE          BAS$LINKAGE            BAS$INIT_R8            BAS$END_R8
BAS$PRINT            BAS$IO_END             BAS$OUT_F_V_B


LISTER$MAIN  Listing Tester  19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   5
      18
Qualifier summary            19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2
DEFAULT DATA TYPE INFORMATION:          LISTING FILE INFORMATION INCLUDES:
    Data type : REAL                          List
    Real size : SINGLE                        Cross reference
    Integer size : LONG                       CDD/Plus Definitions
    Decimal size : (15,2)                     Environment
    Scale factor : 0                       NO Override of %NOLIST
    NO Round decimal numbers                  Machine code
                                              Map
COMPILATION QUALIFIERS IN EFFECT:             INCLUDE files
       Object file
       Overflow check integers          FLAGGERS:
       Overflow check decimal numbers      NO Declining features
       Bounds checking                     NO BASIC PLUS 2 subset
    NO Syntax checking
       Line
       Variant : 0                      DEBUG INFORMATION:
       Warnings                               Traceback records
       Informationals                      NO Debug symbol records
       Setup
       Object Libraries : NONE

LISTER$MAIN  Listing Tester  19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   6
      19
Generated code               19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2

                                0000:          .TITLE  LISTER$MAIN
                                0000:          .IDENT  V1.5
                                0000:          .PSECT  $PDATA
                      0000005F  0000:          .LONG   95
                      0000005C  0004:          .LONG   92
                      1C000103  0008:          .LONG   469762307
```

(continued on next page)

```
                   00000058  000C:            .LONG    88
                   00000000  0010:            .LONG    0
                   00000001  0014:            .LONG    1
                   00000000  0018:            .LONG    0
                   00000000  001C:            .LONG    0
                   00000000  0020:            .LONG    0
                   00000000  0024:            .LONG    0
                   00000000  0028:            .LONG    0
                   00000000  002C:            .LONG    0
                   00000018  0030:            .LONG    24
                   00000000  0034:            .LONG    0
                   00000000  0038:            .LONG    0
                   0000005F  003C:            .LONG    95
                   0000005F  0040:            .LONG    95
                   00000000  0044:            .LONG    0
                   0000005F  0048:            .LONG    95
                   0000006C  004C:            .LONG    108
                   00000000  0050:            .LONG    0
                   0000006C  0054:            .LONG    108
                   00000060  0058:            .LONG    96
       52 45 54 53 49 4C 06  005C:            .ASCIC   "LISTER"
                             0063:            ;        Decimal constants
                         0C  0063:            .PACKED +0
                             0064:            ;        String constants
                             0064:            ;        ERL table
                   00000002  0064:            .LONG    2
                       000A  0068:            .WORD    10
                       0016  006A:            .WORD    22
                       7FFF  006C:            .WORD    32767
                       008E  006E:            .WORD    142
                             0070:
                             0000:            .PSECT   $CODE
                             0000:  LISTER$MAIN::
                       CFFC  0000:            .WORD    ^M<R2,R3,R4,R5,R6,R7,R8,R9,
                                                       R10,R11,IV,DV>
                52 FB AF 9E  0002:            MOVAB    .-3, R2
          50 00000004 0G 9E  0006:            MOVAB    $PDATA+4, R0
                   51 50 D0  000D:            MOVL     R0, R1
             00000000 GG 16  0010:            JSB      BAS$INIT_R8
                             0016:  $T_0016:
             FC AD FD AF 9E  0016:  $L_10:    MOVAB    $L_10, -4(FP)          ; 0025
```

(continued on next page)

```
                                001B:  FIRST_LOOP:
              FC AD FD AF 9E   001B:            MOVAB    .-1, -4(FP)
                 6F AB 00 D0   0020:            MOVL     #0, INDEX(R11)
              FC AD FD AF 9E   0024:  $T_0024:MOVAB    .-1, -4(FP)
                       00 DD   0029:            PUSHL    #0                        ; 0026
        00000000 GG 01 FB   002B:            CALLS    #1, BAS$PRINT
  5C 00 01 05 00 6F AB 0A   0032:            INDEX    INDEX(R11), #0, #5, #1, #0, R12
           7E 57 AB 4C 50   003A:            MOVF     Q(R11)[R12], -(SP)
        00000000 GG 01 FB   003F:            CALLS    #1, BAS$OUT_F_V_B
        00000000 GG 00 FB   0046:            CALLS    #0, BAS$IO_END
              FC AD FD AF 9E   004D:  $T_004D:MOVAB    .-1, -4(FP)               ; 0027

LISTER$MAIN    Listing Tester 19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   7
Generated                     19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2

              CD 6F AB 05 F3   0052:            AOBLEQ   #5, INDEX(R11), $T_0024
                    6F AB D7   0057:            DECL     INDEX(R11)
              FC AD FD AF 9E   005A:  $T_005A:MOVAB    .-1, -4(FP)
                               005F:  SECOND_LOOP:                             ; 0030
              FC AD FD AF 9E   005F:            MOVAB    .-1, -4(FP)
              FC AD FD AF 9E   0064:  $T_0064:MOVAB    .-1, -4(FP)
              FFFFFFFF 8F D5   0069:            TSTL     #-1
                       18 13   006F:            BEQL     $T_0089
                 5C 6F AB 4E   0071:            CVTLF    INDEX(R11), R12           ; 0031
                    5C 08 40   0075:            ADDF2    #8, R12
                 6F AB 5C 4A   0078:            CVTFL    R12, INDEX(R11)
                 5C 6F AB 4E   007C:            CVTLF    INDEX(R11), R12           ; 0032
                    1A 5C 51   0080:            CMPF     R12, #26
                       02 19   0083:            BLSS     $T_0087
                       02 11   0085:            BRB      $T_0089
                       DB 11   0087:  $T_0087:BRB      $T_0064                   ; 0033
              FC AD FD AF 9E   0089:  $T_0089:MOVAB    .-1, -4(FP)
                               008E:
                               008E:  $L_32767:                                ; 0035
              FC AD FD AF 9E   008E:            MOVAB    $L_32767, -4(FP)
         50 00000004 0G 9E   0093:            MOVAB    $PDATA+4, R0
           00000000 GG 16   009A:            JSB      BAS$END_R8
                    50 01 D0   00A0:            MOVL     #1, R0
                          04   00A3:            RET
                               00A4:            .END                           ; 0036
```

4.2.3.1 Source Program Listing

The source program section of the compiler listing contains the source code plus listing line numbers generated by the compiler, as shown in Example 4–2.

Example 4–2: Source Program Listing

```
❶                                          ❷                   ❸                ❹
LISTER$MAIN  Listing Tester   19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   1
                                           ❺                         ❻
V1.5         Test             19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2
  ❼
    1          10      %TITLE "Listing Tester"
    2                  %SBTTL "Test"
    3                  %IDENT "V1.5"
    4
    5                  !This program only shows the format of a listing
    6                  !file.  It does no useful work.
    7
    8  ❽                %INCLUDE "MAPS.DEF"
    9  I1               ! MAPS definition file
   10  I1              MAP (SHARED)     STRING A = 16,     &
   11  I1                               LONG B,            &
   12  I1                               DOUBLE C,          &
   13  I1                               BYTE D
   14                  DECLARE INTEGER INDEX
   15                  DECLARE LONG CONSTANT TRUE = -1
   16                  DECLARE SINGLE Q(5)
   17
   18                  %IF %VARIANT = 2
   19   ❾               %THEN
   20    F1                  DECLARE DOUBLE Z(10)
   21                  %END %IF
   22
   23
   24             First_loop:
   25                  FOR INDEX = 0 TO 5
   26                    PRINT Q(INDEX)
   27                  NEXT INDEX
   28
   29             Second_loop:
   30                  WHILE TRUE
   31                    INDEX = INDEX + 1
   32                    EXIT Second_loop IF INDEX => 5
   33                  NEXT
   34
   35          32767   END
   36
```

❶ The module name, which corresponds to the name in the program or module heading.

❷ The date (day, month, year) and time (hour, minute, second) of compilation.

❸ The VAX BASIC compiler name and version number.

❹ The page number.

❺ The date (day, month, year) and time (hour, minute, second) of source file creation.

❻ The VMS file specification of the source file that is being compiled.

❼ The source code listing line numbers.

The compiler assigns unique line numbers to the lines of source code in a BASIC compilation unit. These line numbers appear in the leftmost column of the source code listing. The symbolic traceback that is printed if your program encounters an error at run time refers to these line numbers; in addition, the VMS Debugger uses these line numbers when controlling program execution.

❽ The %INCLUDE file information.

The I tells you that this code was extracted from a %INCLUDE file. The number following the I tells you the depth of nested %INCLUDE directives. Because this %INCLUDE directive occurs in the source program, the number is 1. If the %INCLUDE file itself contained a %INCLUDE directive, the code extracted from that file would be numbered 2, and so on.

❾ A true-false flag for the %IF...THEN...ELSE...END...IF directives.

Lines marked with T are compiled. Lines marked with F are not compiled.

4.2.3.2 Cross-Reference Listing

If you specified the /CROSS_REFERENCE qualifier, your listing includes a section displaying a list of the names of every identifier, both predeclared and user-declared, and every label to which the source code refers. Example 4–3 displays this information.

Example 4–3: Cross-Reference Listing

```
LISTER$MAIN  Listing Tester  19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   2
Cross Reference              19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2

User Identifier Cross Reference

Symbol                                      Datatype   Name Type

        +----------------------------------------------------+
        !    #  Defining reference                           !
        !    @  Destructive reference                        !
        !    P  Parameter reference                          !
        !    R  Redefining reference                         !
        +----------------------------------------------------+

A                                           STR=16     MAP            SHARED + 0
             10 #
B                                           LONG       MAP            SHARED + 16
             11 #
C                                           DOUBLE     MAP            SHARED + 20
             12 #
D                                           BYTE       MAP            SHARED + 28
             13 #
INDEX                                       LONG
             14 #           25                 26             27             31 @     32
Q()                                         SINGLE
             16 #           26
TRUE                                        LONG       CONSTANT
             15 #           30
LISTER$MAIN      Listing Tester 19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   3
Cross Reference  Map            19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2

Map Cross Reference

Symbol                                      References

SHARED                                                 MAP
             10 #
A                                           STR=16     MAP            SHARED + 0
             10 #
B                                           LONG       MAP            SHARED + 16
             11 #
C                                           DOUBLE     MAP            SHARED + 20
             12 #
```

(continued on next page)

Example 4–3 (Cont.): Cross-Reference Listing

```
D                                              BYTE       MAP            SHARED + 28
            13 #

   ⓬
Label Cross Reference

Symbol                                         References

FIRST_LOOP
            24 #

SECOND_LOOP
            29 #                           32
```

⓾ The cross-reference listing for variables and named constants.

This tells you the variable names, the line number (if any) and statement at which they are referenced, their data type, the PSECT containing them (if any), and their offset from the start of the PSECT.

⓫ The cross-reference listing for mapped variables.

This tells you the variable names, the line number and statement number at which they are referenced, their data type, and their offset from the start of the MAP PSECT.

⓬ The label cross-reference listing for labels.

This tells you the label names and the line number and statement at which they are referenced.

4.2.3.3 Allocation Map

The allocation map portion of a compiler listing contains summary information on program sections, variables, and arrays. If you specified the /CROSS_REFERENCE in addition to the /LISTING qualifier, the allocation map also contains the following cross-reference information:

- Listing lines where symbols are defined and initialized
- Listing lines where the values of symbols are modified
- Listing lines where symbols are actual arguments
- Number of times a symbol occurs in each line

```
LISTER$MAIN   Listing Tester   19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   4
              ALLOCATION MAP   19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2

   ⓭
Allocation information for MAP SHARED

Name                                Offset    Size      Type

A                                   0         16        Static string
B                                   16        4         Long
C                                   20        8         Double
D                                   28        1         Byte
   ⓮
Named constants

Name                                Type           Value

TRUE                                Long           -1

   ⓯
Allocation information for main program LISTER  Offset based on (R11)

Name                                Offset    Size      Type

INDEX                               111       4         Long
Q                                   87        24        Single
   Dimensions : ( 0 TO 5 )
   ⓰
PROGRAM SECTIONS

    Name                        Bytes  Attributes

0 $PDATA                          112  PIC CON REL LCL   SHR NOEXE   RD NOWRT LONG
1 $CODE                           164  PIC CON REL LCL   SHR   EXE   RD NOWRT LONG
2 $ARRAY                            0  PIC CON REL LCL NOSHR NOEXE   RD   WRT LONG
3 $DESC                             0  PIC CON REL LCL NOSHR NOEXE   RD   WRT LONG
4 SHARED                           29  PIC OVR REL GBL   SHR NOEXE   RD   WRT LONG
   ⓱
EXTERNAL REFERENCES

OTS$LINKAGE          BAS$LINKAGE               BAS$INIT_R8            BAS$END_R8
BAS$PRINT            BAS$IO_END                BAS$OUT_F_V_B
```

⓭ The allocation listing for the MAP named SHARED.

This tells you the names of all variables in the MAP, their offset, in bytes, from the beginning of the MAP, their size in bytes, and their data type.

⓮ A list of named constants.

This tells you the names of all explicitly declared constants, their data type, and the value assigned to them.

15 The allocation listing for dynamic variables.

This part of the listing applies to variables that are neither parameters nor part of a COMMON or MAP PSECT. This tells you the names of the variables, their offset from R11, their size in bytes, and their data type.

16 A list of the program sections (PSECTs).

This tells you the names of the PSECTs, their size in bytes, and their attributes. See the *VMS Linker Utility Manual* for more information on PSECT attributes.

17 A list of all external references.

This includes subprograms, external variables, constants, functions, and routines, and the RTL routines invoked to support VAX BASIC language elements. See the *VMS Run-Time Library Routines Volume* for more information on these RTL routines.

4.2.3.4 Qualifier Summary

The compilation summary in Example 4–4 lists the qualifiers used with the BASIC command and the compilation statistics.

Example 4–4: Qualifier Summary

```
LISTER$MAIN  Listing Tester  19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   5
    18
Qualifier summary            19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2
DEFAULT DATA TYPE INFORMATION:           LISTING FILE INFORMATION INCLUDES:
    Data type : REAL                           List
    Real size : SINGLE                         Cross reference
    Integer size : LONG                        CDD/Plus Definitions
    Decimal size : (15,2)                      Environment
    Scale factor : 0                        NO Override of %NOLIST
    NO Round decimal numbers                   Machine code
                                               Map
COMPILATION QUALIFIERS IN EFFECT:              INCLUDE files
       Object file
       Overflow check integers           FLAGGERS:
       Overflow check decimal numbers       NO Declining features
       Bounds checking                      NO BASIC PLUS 2 subset
```

(continued on next page)

Example 4–4 (Cont.): Qualifier Summary

```
NO Syntax checking
   Line
   Variant : 0                        DEBUG INFORMATION:
   Warnings                                 Traceback records
   Informationals                        NO Debug symbol records
   Setup
   Object Libraries : NONE
```

18 A list of the compiler defaults in effect when the program was compiled.

4.2.3.5 Machine Code Listing

If you specified the /MACHINE qualifier, your listing includes a section displaying compiler-generated object code, as shown in Example 4–5.

Example 4–5: Machine Code Listing

```
LISTER$MAIN  Listing Tester  19-OCT-1989 11:27:36  VAX BASIC V3.4     Page   6
   19
Generated code               19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2
                                0000:          .TITLE  LISTER$MAIN
                                0000:          .IDENT  V1.5
                                0000:          .PSECT  $PDATA
                      0000005F  0000:          .LONG   95
                      0000005C  0004:          .LONG   92
                      1C000103  0008:          .LONG   469762307
                      00000058  000C:          .LONG   88
                      00000000  0010:          .LONG   0
                      00000001  0014:          .LONG   1
                      00000000  0018:          .LONG   0
                      00000000  001C:          .LONG   0
                      00000000  0020:          .LONG   0
                      00000000  0024:          .LONG   0
                      00000000  0028:          .LONG   0
                      00000000  002C:          .LONG   0
                      00000018  0030:          .LONG   24
                      00000000  0034:          .LONG   0
                      00000000  0038:          .LONG   0
                      0000005F  003C:          .LONG   95
                      0000005F  0040:          .LONG   95
```

(continued on next page)

```
                00000000  0044:         .LONG   0
                0000005F  0048:         .LONG   95
                0000006C  004C:         .LONG   108
                00000000  0050:         .LONG   0
                0000006C  0054:         .LONG   108
                00000060  0058:         .LONG   96
    52 45 54 53 49 4C 06  005C:         .ASCIC  "LISTER"
                          0063:         ;       Decimal constants
                      0C  0063:         .PACKED +0
                          0064:         ;       String constants
                          0064:         ;       ERL table
                00000002  0064:         .LONG   2
                    000A  0068:         .WORD   10
                    0016  006A:         .WORD   22
                    7FFF  006C:         .WORD   32767
                    008E  006E:         .WORD   142
                          0070:
                          0000:         .PSECT  $CODE
                          0000: LISTER$MAIN::
                    CFFC  0000:         .WORD   ^M<R2,R3,R4,R5,R6,R7,R8,R9,
                                                R10,R11,IV,DV>
             52 FB AF 9E  0002:         MOVAB   .-3, R2
       50 00000004 0G 9E  0006:         MOVAB   $PDATA+4, R0
                51 50 D0  000D:         MOVL    R0, R1
          00000000 GG 16  0010:         JSB     BAS$INIT_R8
                          0016: $T_0016:
          FC AD FD AF 9E  0016: $L_10:  MOVAB   $L_10, -4(FP)             ; 0025
                          001B: FIRST_LOOP:
          FC AD FD AF 9E  001B:         MOVAB   .-1, -4(FP)
             6F AB 00 D0  0020:         MOVL    #0, INDEX(R11)
          FC AD FD AF 9E  0024: $T_0024:MOVAB   .-1, -4(FP)
                   00 DD  0029:         PUSHL   #0                        ; 0026
       00000000 GG 01 FB  002B:         CALLS   #1, BAS$PRINT
 5C 00 01 05 00 6F AB 0A  0032:         INDEX   INDEX(R11), #0, #5, #1, #0, R12
          7E 57 AB 4C 50  003A:         MOVF    Q(R11)[R12], -(SP)
       00000000 GG 01 FB  003F:         CALLS   #1, BAS$OUT_F_V_B
       00000000 GG 00 FB  0046:         CALLS   #0, BAS$IO_END
          FC AD FD AF 9E  004D: $T_004D:MOVAB   .-1, -4(FP)               ; 0027

LISTER$MAIN   Listing Tester 19-OCT-1989 11:27:36  VAX BASIC V3.4      Page   7
Generated                    19-OCT-1989 11:10:56  MY$$DISK:[SMITH]LISTER.BAS;2

          CD 6F AB 05 F3  0052:         AOBLEQ  #5, INDEX(R11), $T_0024
                6F AB D7  0057:         DECL    INDEX(R11)
          FC AD FD AF 9E  005A: $T_005A:MOVAB   .-1, -4(FP)
                          005F: SECOND_LOOP:                              ; 0030
          FC AD FD AF 9E  005F:         MOVAB   .-1, -4(FP)
          FC AD FD AF 9E  0064: $T_0064:MOVAB   .-1, -4(FP)
          FFFFFFFF 8F D5  0069:         TSTL    #-1
                   18 13  006F:         BEQL    $T_0089
             5C 6F AB 4E  0071:         CVTLF   INDEX(R11), R12           ; 0031
                5C 08 40  0075:         ADDF2   #8, R12
```

(continued on next page)

```
         6F AB 5C 4A   0078:              CVTFL    R12, INDEX(R11)
         5C 6F AB 4E   007C:              CVTLF    INDEX(R11), R12          ; 0032
            1A 5C 51   0080:              CMPF     R12, #26
               02 19   0083:              BLSS     $T_0087
               02 11   0085:              BRB      $T_0089
               DB 11   0087:    $T_0087:BRB      $T_0064                  ; 0033
      FC AD FD AF 9E   0089:    $T_0089:MOVAB    .-1, -4(FP)
                       008E:
                       008E:    $L_32767:                                 ; 0035
      FC AD FD AF 9E   008E:              MOVAB    $L_32767, -4(FP)
   50 00000004 0G 9E   0093:              MOVAB    $PDATA+4, R0
      00000000 GG 16   009A:              JSB      BAS$END_R8
            50 01 D0   00A0:              MOVL     #1, R0
                  04   00A3:              RET
                       00A4:              .END                            ; 0036
```

⓲ A list of the compiler-generated machine code.

For a thorough understanding of this code, you should be an experienced VAX MACRO programmer. The naming scheme for the compiler-generated labels is explained as follows:

- Symbols beginning with $L_*n* are line-number labels, where *n* is the line number.
- Symbols beginning with $T_*n* are compiler-generated labels, where *n* is the relative PC of the location.

Note that these labels are used to improve the readability of the listing and are not accessible from the VMS Debugger. See the *VMS Run-Time Library Routines Volume* for more information on BAS$ and OTS$ routines.

4.3 Linking a VAX BASIC Program

On VMS systems, the linker simplifies the job of each language compiler because the logic needed to resolve symbolic references need not be duplicated. The main advantage to a system that has a linker, however, is that individual program modules can be separately written and compiled, and then linked together. This includes object modules produced by different language compilers.

The VMS Linker performs the following functions:

- Resolves local and global symbolic references in the object code
- Assigns values to the global symbolic references

- Signals an error message for any unresolved symbolic reference
- Produces an executable image

When using the LINK command on development systems, you may want to use the /DEBUG qualifier when you link your program module. The /DEBUG qualifier appends to the image all the symbol and line number information appended to the object modules plus information on global symbols, and forces the image to run under debugger control when it is executed.

The LINK command produces an executable image by default. However, you can also use the LINK command to obtain shareable images and system images. The /SHAREABLE qualifier directs the linker to produce a shareable image; the /SYSTEM qualifier a system image. See Section 4.3.2 for a complete description of these and other LINK command qualifiers.

For a complete discussion of the VMS Linker, refer to the *VMS Linker Utility Manual*.

4.3.1 The LINK Command

Once you have compiled your source program or module, you link it by using the DCL command LINK. The LINK command combines your object modules into one executable image, which can then be executed by the VMS system. A source program or module cannot run on the VMS system until it is linked. The format of the LINK command is as follows:

```
LINK[/command-qualifier]... {file-spec[/file-qualifier...]},...
```

/command-qualifier
Specifies one or more output file options.

file-spec
Specifies the input file or files to be linked.

/file-qualifier
Specifies one or more input file options.

If you specify more than one input file, you must separate the input file specifications with plus signs (+) or commas (,). By default, the linker creates an output file with the name of the first input file specified and the file type EXE. When you link more than one file, it is good practice to list the file containing the main program first. In this way, the name of your output file will have the same name as that of your main program module.

The following command line links the object files DANCE.OBJ, CHACHA.OBJ, and SWING.OBJ to produce one executable image called DANCE.EXE:

```
$ LINK DANCE.OBJ, CHACHA.OBJ, SWING.OBJ
```

4.3.2 LINK Command Qualifiers

The LINK command qualifiers can be used to modify the linker's output, as well as to invoke the debugging and traceback facilities. Linker output consists of an image file and an optional map file. Image file qualifiers, map file qualifiers, and debugging and traceback qualifiers are described in this section.

The following list summarizes some of the most commonly used LINK command qualifiers. A brief description of each qualifier follows this list. For a complete list and description of LINK qualifiers, see the *VMS Linker Utility Manual*.

Command Qualifier	Default
/BRIEF	/Default map
/[NO]CROSS_REFERENCE	/NOCROSS_REFERENCE
/[NO]DEBUG [= file-spec]	/NODEBUG
/[NO]EXECUTABLE [= file-spec]	/EXECUTABLE
/FULL	/Default map
/[NO]MAP [= file-spec]	/NOMAP
/[NO]SHAREABLE [= file-spec]	/NOSHAREABLE
/[NO]TRACEBACK	/TRACEBACK

/BRIEF
The /BRIEF qualifier causes the linker to produce a summary of the image's characteristics and a list of contributing modules.

/[NO]CROSS_REFERENCE
The /CROSS_REFERENCE qualifier causes the linker to produce cross-reference information for global symbols; the /NOCROSS_REFERENCE qualifier causes the linker to suppress cross-reference information. The default is /NOCROSS_REFERENCE.

/[NO]DEBUG
The /DEBUG qualifier causes the linker to include the VMS Debugger in the executable image and generates a symbol table; the /NODEBUG qualifier causes the linker to prevent debugger control of the program. The default is /NODEBUG.

/[NO]EXECUTABLE
The /EXECUTABLE qualifier causes the linker to produce an executable image; the /NOEXECUTABLE qualifier suppresses production of an image file. The default is /EXECUTABLE.

/FULL
The /FULL qualifier causes the linker to produce a summary of the image's characteristics, a list of contributing modules, listings of global symbols by name and by value, and a summary of characteristics of image sections in the linked image.

/[NO]MAP
The /MAP qualifier causes the linker to generate a map file; the /NOMAP qualifier suppresses the map. The default is /MAP in batch mode and /NOMAP in interactive mode.

/[NO]SHAREABLE
The /SHAREABLE qualifier causes the linker to create a shareable image; the /NOSHAREABLE qualifier generates an executable image. The default is /NOSHAREABLE.

/[NO]TRACEBACK
The /TRACEBACK qualifier causes the linker to generate symbolic traceback information when error messages are produced; the /NOTRACEBACK qualifier suppresses traceback information. The default is /TRACEBACK.

4.3.3 Linker Input Files

You can specify the object modules to be included in an executable image in any of the following ways:

- Specify input file specifications for the object modules.

  If no file type is specified, the linker assumes that an input file is an object file with the file type OBJ.

- Specify one or more object module library files.

  You can either specify the name of an object module library with the /LIBRARY qualifier, or specify the names of object modules contained in an object module library with the /INCLUDE qualifier. The uses of object module libraries are described in Section 4.3.5.

- Specify an options file.

An options file can contain additional file specifications for the LINK command as well as special linker options. You must use the /OPTIONS qualifier to specify an options file. For more information on options files see the *VMS Linker Utility Manual.*

The linker uses the following default file types for input files:

File	File Type
Object module	OBJ
Library	OLB
Options file	OPT

4.3.4 Linker Output Files

When you enter the LINK command interactively and do not specify any qualifiers, the linker creates only an executable image file. By default, the resulting image file has the same file name as the first object module specified, and a file type of EXE.

In a batch job, the linker creates both an executable image file and a storage map file by default. The default file type for map files is MAP.

To specify an alternative name for a map file or image file, or to specify an alternative output directory or device, you can include a file specification on the /MAP or /EXECUTABLE qualifier. For example:

```
$  LINK UPDATE/MAP=TEST
```

4.3.5 Using an Object Module Library

In a large development effort, the object modules for subprograms are often stored in an object module library. By using an object module library, you can make program modules contained in the library available to many other programmers. To link modules contained in an object module library, use the /INCLUDE qualifier and specify the specific modules you want to link. For example:

```
$  LINK GARDEN, VEGGIES/INCLUDE=(EGGPLANT,TOMATO,BROCCOLI,ONION)
```

This example directs the linker to link the subprogram modules EGGPLANT, TOMATO, BROCCOLI, and ONION with the main program module GARDEN.

Besides program modules, an object module library can also contain a symbol table with the names of each global symbol in the library, and the name of the module in which they are defined. You specify the name of the object module library containing symbol definitions with the /LIBRARY qualifier. When you use the /LIBRARY qualifier during a link operation, the linker searches the specified library for all unresolved references found in the included modules during compilation.

In the following example, the linker uses the library RACQUETS to resolve undefined symbols in BADMINTON, TENNIS, and RACQUETBALL.

```
$ LINK BADMINTON, TENNIS, RACQUETBALL, RACQUETS/LIBRARY
```

You can define an object module library, such as LNK$LIBRARY, to be your default library by using the DCL command DEFINE. The linker searches default user libraries for unresolved references after it searches modules and libraries specified in the LINK command. See the *VMS DCL Dictionary* for more information about the DEFINE command.

For more information about object module libraries, see the *VMS Linker Utility Manual*.

4.3.6 Linker Error Messages

If the linker detects any errors while linking object modules, it displays messages indicating the cause and severity of the error. If any error or fatal error conditions occur (errors with severities of E or F), the linker does not produce an image file.

The messages produced by the linker are descriptive, and you do not usually need additional information to determine the specific error. Some common errors that occur during linking are as follows:

- An object module has compilation errors.

  This error occurs when you attempt to link a module that has warnings or errors during compilation. You can usually link compiled modules for which the compiler generated messages, but you should verify that the modules will actually produce the output you expect.

- The input file has a file type other than OBJ and no file type was specified on the command line.

  If you do not specify a file type, the linker assumes the file has a file type of OBJ by default. If the file is not an object file and you do not identify it with the appropriate file type, the linker signals an error message and does not produce an image file.

- You tried to link a nonexistent module.

The linker signals an error message if you misspell a module name on the command line or if the compilation contains fatal diagnostics.

- A reference to a symbol name remains unresolved.

  An error occurs when you omit required module or library names from the command line and the linker cannot locate the definition for a specified global symbol reference. For example, a main program module OCEAN.OBJ calls the subprograms REEF.OBJ, SHELLS.OBJ, and SEAWEED.OBJ. However, the following LINK command does not reference SEAWEED.OBJ:

  ```
  $ LINK OCEAN, REEF, SHELLS
  ```

  This example produces the following error messages:

  ```
  %LINK-W-NUDFSYMS, 1 undefined symbol
  %LINK-I-UDFSYMS,        SEAWEED
  %LINK-W-USEUNDEF, module "OCEAN" references undefined symbol "SEAWEED"
  %LINK-W-DIAGISUED, completed but with diagnostics
  ```

If an error occurs when you link modules, you can often correct the error by reentering the command string and specifying the correct modules or libraries.

See the *VMS System Messages and Recovery Procedures* for a complete list of linker messages.

4.4 Running a VAX BASIC Program

Once you have linked your program, you use the DCL command RUN to execute it. The RUN command has the following format:

RUN [/[NO]DEBUG] file-spec [/[NO]DEBUG]

/[NO]DEBUG
The /[NO]DEBUG qualifier is optional. Specify the /DEBUG qualifier to request the debugger if the image was not linked with it. You cannot use /DEBUG on images linked with the /NOTRACEBACK qualifier. If the image was linked with the /DEBUG qualifier and you do not want the debugger to prompt, use the /NODEBUG qualifier. The default action depends on whether the file was linked with the /DEBUG qualifier.

file-spec
The name of the file you want to run.

The following example executes the image SAMPLE.EXE without invoking the debugger:

```
$ RUN SAMPLE/NODEBUG
```

See Chapter 5 for more information on debugging programs.

During program execution, an image can generate a fatal error called an *exception condition*. When an exception condition occurs, VAX BASIC displays an error message. Run-time errors can also be issued by other facilities, such as the VMS operating system. For more information on run-time errors, see Appendix B.

Chapter 5

Using the VMS Debugger

This chapter is an introduction to using the VMS Debugger with VAX BASIC programs. Included in the chapter are the following:

- An overview of the debugger
- Enough information to get you started using the debugger
- A sample terminal session that demonstrates using the debugger to find a bug in a VAX BASIC program
- A list of the debugger commands by function

For complete reference information on the VMS Debugger, see the *VMS Debugger Reference Manual.* Online HELP is available during debugging sessions.

5.1 Overview of the Debugger

A debugger is a tool to help you locate run-time errors quickly. It is used with a program that has already been compiled and linked successfully, with no errors reported, but that does not run correctly. For example, the output may be obviously wrong, or the program goes into an infinite loop or terminates prematurely. The debugger enables you to observe and manipulate the program's execution interactively, step by step, until you locate the point at which the program stopped working correctly.

The VMS Debugger is a *symbolic* debugger, which means that you can refer to program locations by the symbols (names) you used for those locations in your program—the names of variables, routines, labels, and so on. You do not have to use virtual addresses to refer to memory locations.

The debugger recognizes the syntax, expressions, data typing, and other constructs of VAX BASIC, as well as the following other VMS-supported languages:

Ada®
BLISS
C
COBOL
DIBOL
FORTRAN
MACRO-32
Pascal
PL/I
RPG II
SCAN

Therefore, if your program is written in more than one language, you can change from one language to another in the course of a debugging session. The current source language determines the format used for entering and displaying data, as well as other features that have language-specific settings (for example, comment characters, operators and operator precedence, and case sensitivity or insensitivity).

By issuing debugger commands at your terminal, you can:

- Start, stop, and resume the program's execution
- Trace the execution path of the program
- Monitor selected locations, variables, or events
- Examine and modify the contents of variables, or force events to occur
- Test the effect of some program modifications without having to edit, recompile, and relink the program

Such techniques can enable you to isolate an error in your code much more quickly than you could without the debugger.

Once you have found the error in the program, you can then edit the source code and compile, link, and run the corrected version.

® Ada is a registered trademark of the U.S. Government (Ada Joint Program Office).

5.2 Features of the Debugger

The VMS Debugger provides various features that help you to debug your programs:

- Online HELP. Online HELP is always available during a debugging session; it contains information on all the debugger commands and selected topics.
- Source code display. The debugger lets you display lines of source code during a debugging session.
- Screen mode. In screen mode, you can display and capture various kinds of information in scrollable windows that can be moved around the screen and resized. Source, instruction, and register displays are automatically updated. You can selectively direct debugger input, output, and diagnostic messages to displays. (Screen mode is best displayed on VT100-series or VT200-series terminals or MicroVMS workstations.)
- Keypad mode. When you invoke the debugger, several commonly used debugger command sequences are assigned by default to the keys of the numeric keypad (if you have a VT100, VT52, or LK201 keypad). Using the keypad can be more efficient than typing commands because the keypad keys can save keystrokes. (See Figure 5–1 for a diagram of the keypad key functions.)
- Source editing. As you find errors during a debugging session, you can use the EDIT command to invoke any editor available on your system. You specify the editor you want with the SET EDITOR command.
- Command procedures. You can direct the debugger to execute a command procedure (a file of debugger commands) to re-create a debugging session, to continue a previous session, or to avoid typing the same debugger commands many times during a debugging session.
- Symbol definitions. You can define your own symbols to represent lengthy commands, address expressions, or values in abbreviated form.
- Initialization files. You can create an initialization file containing commands to set your default debugging modes, screen display definitions, keypad key definitions, symbol definitions, and so on. In addition, you may want to have special initialization files for debugging specific programs. When you invoke the debugger, those commands will be executed automatically.

- Log files. You can record the commands you enter during a debugging session and the debugger's responses to those commands in a log file. You can use log files to keep track of your debugging efforts, or you can use them as command procedures in subsequent debugging sessions.

5.3 Getting Started with the Debugger

This section explains how to use the debugger and provides VAX BASIC examples. The intent is to get you started using the debugger; therefore, only basic functions are covered. For more detailed information, see the *VMS Debugger Reference Manual*. Remember that online HELP is immediately available to you during a debugging session when you type the HELP command at the DBG> prompt.

5.3.1 Compiling and Linking to Prepare for Debugging

The following example shows how to compile and link a VAX BASIC program (consisting of a single compilation unit named INVENTORY) so that subsequently you will be able to use the debugger:

```
$  BASIC/DEBUG INVENTORY
$  LINK/DEBUG INVENTORY
```

The /DEBUG qualifier on the BASIC command causes the compiler to write the debug symbol records associated with INVENTORY into the object module, INVENTORY.OBJ. These records allow you to use the names of variables and other symbols declared in INVENTORY in debugger commands. (If your program has several compilation units, you must compile each unit that you want to debug with the /DEBUG qualifier.)

The /DEBUG qualifier on the LINK command causes the linker to include all symbol information that is contained in INVENTORY.OBJ in the executable image. The qualifier also causes the VMS image activator to start the debugger at run time. (If your program has several object modules, you may need to specify other modules in the LINK command.)

5.3.1.1 Establishing the Debugging Configuration

Before invoking the debugger as explained in Section 5.3.2, check that the debugging configuration is appropriate for the kind of program you are going to debug.

You can invoke the debugger in either the *default* configuration or the *multiprocess* configuration to debug programs that run in either one or several processes, respectively. The configuration depends on the current definition of the logical name DBG$PROCESS. Thus, before invoking the debugger, enter the DCL command SHOW LOGICAL DBG$PROCESS to determine the definition of DBG$PROCESS.

For programs that run in only one process, DBG$PROCESS either should be undefined, as in the following example, or should have the value DEFAULT:

```
$ SHOW LOGICAL DBG$PROCESS
%SHOW-S-NOTRAN, no translation for logical name DBG$PROCESS
```

If DBG$PROCESS has the value MULTIPROCESS, and you want to debug a program that runs in only one process, enter the following command:

```
$  DEFINE DBG$PROCESS DEFAULT
```

5.3.2 Starting and Terminating a Debugging Session

To invoke the debugger, issue the DCL command RUN. The following message will appear on your screen:

```
$  RUN INVENTORY
                          VAX DEBUG Version 4.n
%DEBUG-I-INITIAL, language is BASIC, module set to 'INVENTORY$MAIN'
DBG>
```

The DBG> prompt indicates that you can now type debugger commands. At this point, if you type the GO command, program execution begins and continues until it is forced to pause or stop (for example, if the program prompts you for input, or an error occurs).

The debugger suspends execution before the start of the main program, so that you can execute initialization code under debugger control. Typing the GO command will put you at the start of the main program. At that point, typing the GO command again will start program execution and continue it until it is forced to stop (for example, if the program prompts you for input, or an error occurs).

If your program goes into an infinite loop during a debugging session so that the debugger prompt does not reappear, press CTRL/C. This interrupts program execution and returns you to the debugger prompt (pressing CTRL/C does not end the debugging session). For example:

```
DBG> GO
        .
        .
        .
CTRL/C
DBG>
```

You can also press CTRL/C to abort the execution of a debugger command. This is useful if a command takes a long time to complete.

If your program already has a CTRL/C AST service routine enabled, use the SET ABORT_KEY command to assign the debugger's abort function to another CTRL/key sequence.

Pressing CTRL/Y from within a debugging session has the same effect as pressing CTRL/Y during the execution of a program. Control is returned to the DCL command interpreter ($ prompt).

The following message indicates that your program has completed successfully:

```
%DEBUG-I-EXITSTATUS, is '%SYSTEM-S-NORMAL, normal successful completion'
DBG>
```

To end a debugging session, type the EXIT command at the DBG> prompt or press CTRL/Z:

```
DBG> EXIT
$
```

If you make changes to a program in the VAX BASIC environment and attempt to compile the program with the /DEBUG qualifier without first saving or replacing the program, VAX BASIC signals the error "Unsaved changes, no source line debugging available". Save or replace the program, and then recompile the program with the /DEBUG qualifier.

5.3.3 Issuing Debugger Commands

You can issue debugger commands any time you see the debugger prompt (DBG>). To enter a command, type it at the keyboard and press the RETURN key. You can issue several commands on a line by separating the command strings with semicolons (;). As with DCL commands, you can continue a command string on a new line by ending the line with a hyphen (–).

Alternatively, you can use the numeric keypad. In addition to the STEP, GO, SHOW CALLS, and EXAMINE commands, several functions that manipulate screen-mode displays are bound to the keys. Figure 5–1

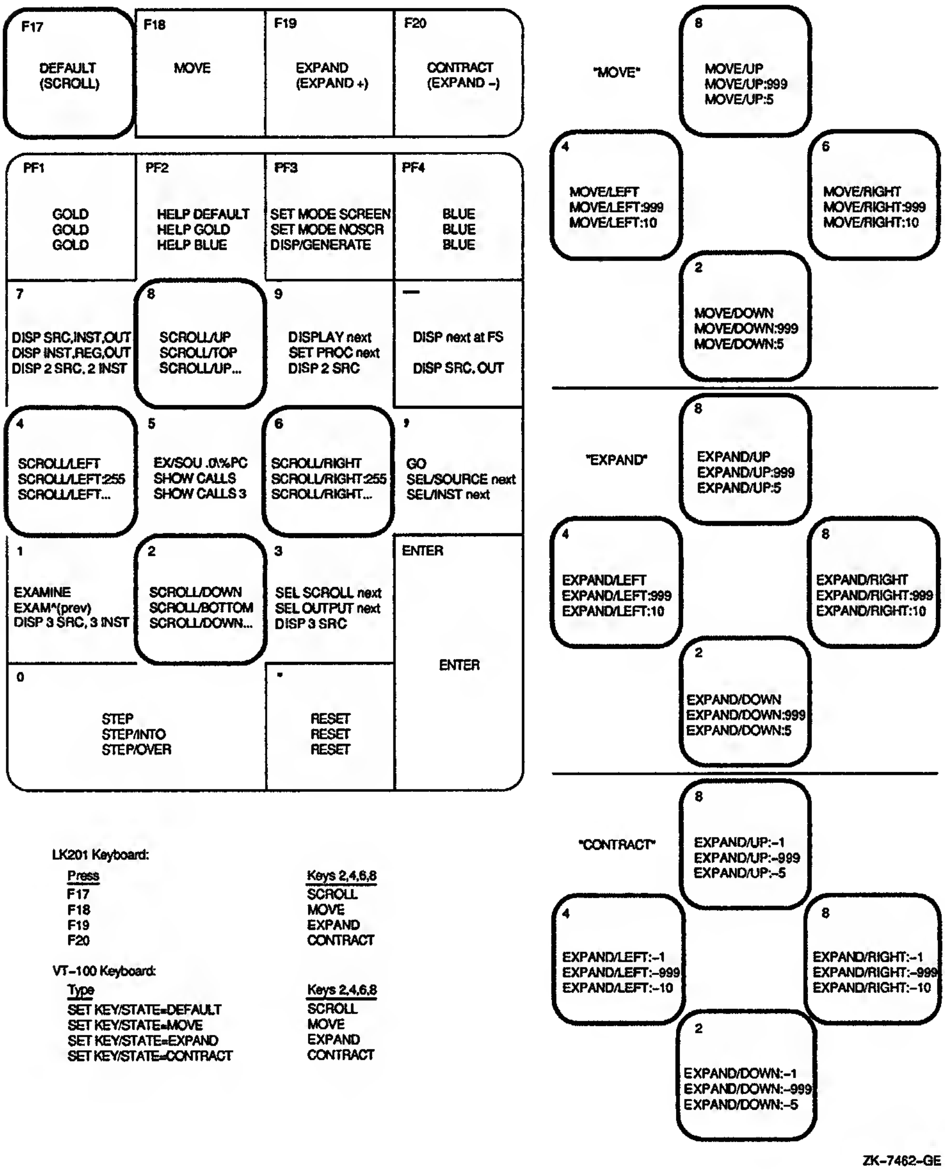
identifies the predefined key functions. You can also redefine key functions with the DEFINE/KEY command.

Most keypad keys have three predefined functions—DEFAULT, GOLD, and BLUE. (The PF1 key is commonly known as the GOLD key, and the PF4 key is commonly known as the BLUE key.) To obtain a key's DEFAULT function, press the key. To obtain its GOLD function, first press the PF1 (GOLD) key, and then the key. To obtain its BLUE function, first press the PF4 (BLUE) key, and then the key.

In Figure 5–1, the DEFAULT, GOLD, and BLUE functions are listed within each key's outline, from top to bottom respectively. For example, pressing keypad key 0 issues the STEP command (DEFAULT function); pressing key PF1 and then key 0 issues the STEP/INTO command (GOLD function); pressing key PF4 and then key 0 issues the STEP/OVER command (BLUE function).

Type the HELP KEYPAD command to get help on the keypad key definitions.

Figure 5–1: Keypad Key Functions Predefined by the Debugger



5.3.4 Viewing Your Source Code

The debugger provides two methods for viewing source code: noscreen mode and screen mode. By default, when you invoke the debugger, you are in noscreen mode, but you may find that it is easier to view your source code with screen mode. Both modes are briefly described in the following sections.

5.3.4.1 Noscreen Mode

Noscreen mode is the default, line-oriented mode of displaying input and output. To get into noscreen mode from screen mode, type SET MODE NOSCREEN. See the sample debugging session in Section 5.4 for a demonstration of noscreen mode.

In noscreen mode, you can use the TYPE command to display one or more source lines. For example, the following command displays line 3 of the module that is currently executing:

```
DBG> TYPE 3
3:    EXTERNAL SUB TRIPLE    &
DBG>
```

The display of source lines is independent of program execution. You can use the TYPE command to display source code from a module other than the one currently executing. In that case, you need to use a *path name* to specify the module. For example, the following command displays lines 16 through 21 of module TEST:

```
DBG> TYPE TEST\16:21
```

5.3.4.2 Screen Mode

To invoke screen mode, press keypad key PF3. In screen mode, by default the debugger splits the screen into three displays named SRC, OUT, and PROMPT.

```
--SRC: module SAMPLE$MAIN -scroll-source--------------------------
     1:  10     !SAMPLE
     2:
     3:         EXTERNAL SUB TRIPLE       &
     4:                     ,PRINT_SUB
     5:
     6:         WHEN ERROR USE HANDLER_1
  -> 7:           CALL TRIPLE
     8:           CALL PRINT_SUB
     9:
- OUT -output-------------------------------------------
stepped to SAMPLE$MAIN\%LINE 7
```

```
- PROMPT -error-program-prompt---------------------------
DBG> STEP
DBG>
```

The SRC display, at the top of the screen, shows the source code of the module (compilation unit) that is currently executing. An arrow in the left column points to the next line to be executed, which corresponds to the current location of the program counter (PC). The line numbers, which are assigned by the compiler, match those in a listing file.

NOTE

> VAX BASIC line numbers are treated as text by the debugger. In this chapter, line numbers refer to the sequential line numbers generated by the compiler. When a program includes or appends code from another file, the included lines of code are also numbered in sequence by the compiler. These line numbers are on the extreme left of a listing file. An explanation of the listing file format can be found in Chapter 4.

The PROMPT display, at the bottom of the screen, shows the debugger prompt (DBG>), your input, debugger diagnostic messages, and program output. In the illustration, it shows the debugger commands that have been issued.

The OUT display, in the center of the screen, captures the debugger's output in response to the commands that you issue.

The SRC and OUT displays are scrollable so that you can see whatever information may scroll beyond the display window's edge. Use keypad key 8 to scroll up and keypad key 2 to scroll down. Use keypad key 3 to change the display to be scrolled (by default, the SRC display is scrolled). Scrolling a display does not affect program execution.

If the debugger cannot locate source lines for the currently executing module, it tries to display source lines in the next module down on the call stack for which source lines are available and issues the following message:

```
%DEBUG-I-SOURCESCOPE, Source lines not available for .0\%PC.
        Displaying source in a caller of the current routine.
```

Source lines may not be available for the following reasons:

- The PC is within a system routine, or a shareable image routine for which no source code is available.
- The PC is within a routine that was compiled without the /DEBUG compiler command qualifier (or with /NODEBUG).

- The source file was moved to a different directory after it was compiled (the location of source files is embedded in the object modules).

5.3.5 Controlling and Monitoring Program Execution

This section covers the following topics:

- Starting and resuming program execution with the GO command
- Stepping through the program's code with the STEP command
- Determining the current location of the program counter (PC) with the SHOW CALLS command
- Suspending program execution with breakpoints
- Tracing program execution with tracepoints
- Monitoring changes in variables with watchpoints

5.3.5.1 Starting and Resuming Program Execution

There are two commands for starting or resuming program execution: GO and STEP. The GO command starts execution. The STEP command lets you execute a specified number of source lines or instructions.

The GO Command

The GO command starts program execution, which continues until forced to stop. You will probably use the GO command most often in conjunction with breakpoints, tracepoints, and watchpoints. If you set a breakpoint in the path of execution and then type the GO command (or press the comma key on the keypad, which executes the GO command), execution will be suspended when the program reaches that breakpoint. If you set a tracepoint, the path of execution through that tracepoint will be monitored. If you set a watchpoint, execution will be suspended when the value of the watched variable changes.

You can also use the GO command to test for an exception condition or an infinite loop. If an exception condition that is not handled by your program occurs, the debugger will take over and display the DBG> prompt so that you can issue commands. If you are using screen mode, the pointer in the source display will indicate where execution stopped. You can then use the SHOW CALLS command (explained in Section 5.3.5.2) to identify the currently active routine calls (the call stack).

In the case of an infinite loop, the program will not terminate, so the debugger prompt will not reappear. To obtain the prompt, interrupt the program by pressing CTRL/Y and then issue the DCL command DEBUG. You can then look at the source display and a SHOW CALLS display to locate the PC.

The STEP Command

The STEP command (which you can use either by typing STEP or by pressing the keypad 0 key) allows you to execute a specified number of source lines or instructions, or to execute the program to the next instruction of a particular kind, for example, to the next CALL instruction.

By default, the STEP command executes a single source line at a time. In the following example, the STEP command executes one line, reports the action ("stepped to . . . "), and displays the line number (27) and source code of the next line to be executed:

```
DBG> STEP
stepped to TEST\COUNTER\%LINE 27
     27:    X = X + 1
DBG>
```

The PC is now at the first machine code instruction for line 27 of the module TEST; line 27 is in COUNTER, a routine within the module TEST. TEST\COUNTER\%LINE 27 is a *path name*. The debugger uses path names to refer to symbols. (However, you do not need to use a path name in referring to a symbol, unless the symbol is not unique; in that case, the debugger will issue an error message. See Section 5.3.7.2 for more information on resolving multiply-defined symbols.)

You can specify a number of lines for the STEP command to execute. In the following example, the STEP command executes three lines:

```
DBG> STEP 3
```

Note that only those source lines for which code instructions were generated by the compiler are recognized as executable lines by the debugger. The debugger skips over any other lines—for example, comment lines.

Also, if a line has more than one statement on it, the debugger will execute all the statements on that line as part of the single step.

You can specify different stepping modes, such as stepping by instruction rather than by line (SET STEP INSTRUCTION). To resume to the default behavior, issue the SET STEP LINE command. Also, by default, the debugger steps over called routines—execution is not suspended within a called routine, although the routine is executed. By issuing the SET STEP INTO command, you tell the debugger to suspend execution within called

routines as well as within the currently executing module. To resume the default behavior, issue the SET STEP OVER command.

5.3.5.2 Determining the Current Location of the Program Counter

The SHOW CALLS command lets you determine the current location of the program counter (PC) (for example, after returning to the debugger following a CTRL/Y interrupt). The command shows a traceback that lists the sequence of calls leading to the currently executing routine. For example:

```
DBG> SHOW CALLS
 module name        routine name        line      rel PC     abs PC

*TEST               PRODUCT               18     00000009   0000063C
*TEST               COUNTER               47     00000009   00000647
*MY_PROG            MY_PROG               21     0000000D   00000653
DBG>
```

For each routine (beginning with the currently executing routine), the debugger displays the following information:

- The name of the module that contains the routine
- The name of the routine
- The line number at which the call was made (or at which execution is suspended, in the case of the current routine)
- The corresponding PC addresses (the relative PC address from the start of the routine and the absolute PC address of the program)

This example indicates that execution is currently at line 18 of routine PRODUCT (in module TEST), which was called from line 47 of routine COUNTER (in module TEST), which was called from line 21 of routine MY_PROG (in module MY_PROG).

5.3.5.3 Suspending Program Execution

The SET BREAK command lets you select breakpoints, which are locations at which the program will stop running. When you reach a breakpoint, you can issue commands to check the call stack, examine the current values of variables, and so on.

A typical use of the SET BREAK command is illustrated in the following example:

```
DBG> SET BREAK COUNTER
DBG> GO
     .
     .
     .
break at TEST\COUNTER
     34:  SUB COUNTER(LONG X,Y)
DBG>
```

In this example, the SET BREAK command sets a breakpoint on the subprogram COUNTER; the GO command starts execution. When the subprogram COUNTER is encountered, execution is suspended, the debugger announces that the breakpoint at COUNTER has been reached (break at . . .), displays the source line (34) where execution is suspended, and prompts you for another command. At this breakpoint, you could step through the subprogram COUNTER, using the STEP command, and use the EXAMINE command (discussed in Section 5.3.6.1) to check on the current values of X and Y.

When using the SET BREAK command, you can specify program locations using various kinds of *address expressions* (for example, line numbers, routine names, instructions, virtual memory addresses, byte offsets). With high-level languages, you typically use routine names, labels, or line numbers, possibly with path names to ensure uniqueness.

Routine names and labels should be specified as they appear in the source code. Line numbers may be derived from either a source code display or a listing file. When specifying a line number, use the prefix %LINE. (Otherwise, the debugger will interpret the line number as a memory location.) For example, the next command sets a breakpoint at line 41 of the currently executing module; the debugger will suspend execution when the PC is at the start of line 41:

```
DBG> SET BREAK %LINE 41
```

Note that you can set breakpoints only on lines that resulted in machine code instructions. The debugger warns you if you try to do otherwise (for example, on a comment line). If you want to pick a line number in a module other than the one currently executing, you need to specify the module's name in a path name. For example:

```
DBG> SET BREAK SCREEN_IO\%LINE 58
```

You do not always have to specify a particular program location, such as line 58 or COUNTER, to set a breakpoint. You can set breakpoints on events, such as exceptions. You can use the SET BREAK command with a qualifier, but no parameter, to break on every line, or on every CALL instruction, and so on. For example:

```
DBG>  SET BREAK/LINE
DBG>  SET BREAK/CALL
```

You can conditionalize a breakpoint (with a WHEN clause) or specify that a list of commands be executed at the breakpoint (with a DO clause on the debugger command). For example, the next command sets a breakpoint on the label LOOP3. The DO (EXAMINE TEMP) clause causes the value of the variable TEMP to be displayed whenever the breakpoint is triggered.

```
DBG>  SET BREAK LOOP3 DO (EXAMINE TEMP)
DBG>  GO
       .
       .
       .
break at COUNTER\LOOP3
     37:     LOOP3: FOR I = 1 TO 10
COUNTER\TEMP:   284.19
DBG>
```

To display the currently active breakpoints, type the SHOW BREAK command:

```
DBG>  SHOW BREAK
breakpoint at SCREEN_IO\%LINE 58
breakpoint at COUNTER\LOOP3
   do (EXAMINE TEMP)
       .
       .
       .
DBG>
```

To cancel a breakpoint, type the CANCEL BREAK command, specifying the program location exactly as you did when setting the breakpoint. The CANCEL BREAK/ALL command cancels all breakpoints.

5.3.5.4 Tracing Program Execution

The SET TRACE command lets you select tracepoints, which are locations for tracing the execution of your program without stopping its execution. After setting a tracepoint, you can start execution with the GO command and then monitor the PC's path, checking for unexpected behavior. By setting a tracepoint on a routine, you can also monitor the number of times the routine is called.

As with breakpoints, every time a tracepoint is reached, the debugger issues a message and displays the source line. It can also display other information that you have specified (as shown in the last example in this section, in which the value of a specified variable is displayed). However, at tracepoints, unlike breakpoints, the program continues executing, and the debugger prompt is not displayed. For example:

```
DBG>  SET TRACE COUNTER
DBG>  GO
     .
     .
     .
trace at TEST\COUNTER
     34:  SUB COUNTER(LONG X,Y)
     .
     .
     .
```

When using the SET TRACE command, you specify address expressions, qualifiers, and optional clauses exactly as with the SET BREAK command.

The /LINE qualifier causes the SET TRACE command to trace every line and is a convenient means of checking the execution path. By default, lines are traced within all called routines as well as the currently executing routine. If you do not want to trace system routines or routines in shareable images, use the /NOSYSTEM or /NOSHARE qualifiers. For example:

```
DBG>  SET TRACE/LINE/NOSYSTEM/NOSHARE
```

The /SILENT qualifier suppresses the trace message and source code display. This is useful when you want to use the SET TRACE command to execute a debugger command at the tracepoint. For example:

```
DBG>  SET TRACE\SILENT %LINE 83 DO (EXAMINE STATUS)
DBG>  GO
     .
     .
     .
SCREEN_IO\CLEAR\STATUS:   'OFF'
     .
     .
     .
```

5.3.5.5 Monitoring Changes in Variables

The SET WATCH command lets you set watchpoints that will be monitored continuously as your program executes.

If the program modifies the value of a *watched* variable, the debugger suspends execution and displays the old and new values.

```
DBG>  SET WATCH TOTAL
```

Subsequently, every time the program modifies the value of TOTAL, the watchpoint is triggered. The debugger monitors watchpoints continuously during program execution.

The next example shows what happens when your program modifies the contents of a watched variable:

```
DBG>  SET WATCH TOTAL
DBG>  GO
    .
    .
    .
watch of SCREEN_IO\TOTAL\%LINE 13
     13:    TOTAL = TOTAL + 1
    old value: 16
    new value: 17
break at SCREEN_IO.%LINE 14
     14:    CALL Pop_rtn(TOTAL)
DBG>
```

In this example, a watchpoint is set on the variable TOTAL and the GO command starts execution. When the value of TOTAL changes, execution is suspended. The debugger announces the event (watch of . . .), identifying where TOTAL changed (line 13) and the associated source line. The debugger then displays the old and new values and announces that execution has been suspended at the start of the next line (14). (The debugger reports break at . . . , but this is not a breakpoint; it is still the effect of the watchpoint.) Finally, the debugger prompts for another command.

When a change in a variable occurs at a point other than the start of a source line, the debugger gives the line number plus the byte offset from the start of the line.

5.3.6 Examining and Manipulating Data

This section explains how to use the EXAMINE, DEPOSIT, and EVALUATE commands to display and modify the contents of variables, and evaluate expressions in VAX BASIC programs.

5.3.6.1 Displaying the Values of Variables

To display the current value of a variable, use the EXAMINE command as follows:

```
DBG> EXAMINE variable_name
```

The debugger recognizes the compiler-generated data type of the specified variable and retrieves and formats the data accordingly. The following examples show some uses of the EXAMINE command.

Examine a string variable:

```
DBG>  EXAMINE EMPLOYEE_NAME
PAYROLL\EMPLOYEE_NAME:    "Peter C. Lombardi"
DBG>
```

Examine three integer variables:

```
DBG>  EXAMINE WIDTH, LENGTH, AREA
SIZE\WIDTH:   4
SIZE\LENGTH:  7
SIZE\AREA:   28
DBG>
```

Examine a two-dimensional array of integers (three per dimension):

```
DBG>  EXAMINE INTEGER_ARRAY
PROG2\INTEGER_ARRAY
   (0,0):       27
   (0,1):       31
   (0,2):       12
   (1,0):       15
   (1,1):       22
   (1,2):       18
DBG>
```

Examine element 4 of a one-dimensional string array:

```
DBG>  EXAMINE CHAR_ARRAY(4)
PROG2\CHAR_ARRAY(4): 'm'
DBG>
```

Note that the EXAMINE command can be used with any kind of address expression (not just a variable name) to display the contents of a program location. The debugger associates certain default data types with untyped locations. You can override the defaults for typed and untyped locations if you want the data to be interpreted and displayed in some other data format. The debugger supports the data types and operators of VAX BASIC including RECORDs and RFAs.

See Section 5.3.6.3 for an explanation of how the EXAMINE and the EVALUATE commands differ.

5.3.6.2 Changing the Values of Variables

To change the value of a variable, use the DEPOSIT command as follows:

```
DBG> DEPOSIT variable_name = value
```

The DEPOSIT command is like an assignment statement in VAX BASIC.

In the following examples, the DEPOSIT command assigns new values to different variables. The debugger checks that the value assigned, which may be a language expression, is consistent with the data type and dimensional constraints of the variable.

Deposit a string value (it must be enclosed in quotation marks or apostrophes):

```
DBG> DEPOSIT PARTNUMBER = "WG-7619.3-84"
```

Deposit an integer expression:

```
DBG> DEPOSIT WIDTH = CURRENT_WIDTH + 10
```

Deposit element 12 of an array of characters (you cannot deposit an entire array aggregate with a single DEPOSIT command, only an element):

```
DBG> DEPOSIT C_ARRAY(12) = 'K'
```

You can specify any kind of address expression, not just a variable name, with the DEPOSIT command (as with the EXAMINE command). You can override the defaults for typed and untyped locations if you want the data to be interpreted in some other data format.

5.3.6.3 Evaluating Expressions

To evaluate a language expression, use the EVALUATE command as follows:

```
DBG> EVALUATE lang_exp
```

The debugger recognizes the operators and expression syntax of the currently set language. In the following example, the value 45 is assigned to the integer variable WIDTH; the EVALUATE command then obtains the sum of the current value of WIDTH plus 7:

```
DBG> DEPOSIT WIDTH = 45
DBG> EVALUATE WIDTH + 7
52
DBG>
```

Following is an example of how the EVALUATE and the EXAMINE commands are similar. When the expression following the command is a variable name, the value reported by the debugger is the same for either command.

```
DBG> DEPOSIT WIDTH = 45
DBG> EVALUATE WIDTH
45
DBG> EXAMINE WIDTH
SIZE\WIDTH:   45
```

Following is an example of how the EVALUATE and EXAMINE commands are different:

```
DBG>  EVALUATE WIDTH + 7
52
DBG>  EXAMINE WIDTH + 7
SIZE\WIDTH:   131584
```

With the EVALUATE command, WIDTH + 7 is interpreted as a language expression, which evaluates to 45 + 7, or 52. With the EXAMINE command, WIDTH + 7 is interpreted as an address expression: 7 bytes are added to the address of WIDTH, and whatever value is in the resulting address is reported (in this instance, 131584).

5.3.6.4 Stepping Into VAX BASIC Routines

This section provides details of the STEP/INTO command that are specific to VAX BASIC.

In the following example, the debugger is waiting to proceed at source line 2. If you issue a STEP command at this point, the debugger will proceed to source line 3 without stopping during the execution of the function call. To examine the source code in the EXTERNAL FUNCTION *extfun*, you must use the STEP/INTO command. A STEP/INTO command entered while the debugger has stopped at source line 2, will cause the debugger to display the source code for *extfun* and stop execution at source code line 63.

```
  1      10  EXTERNAL REAL FUNCTION extfun (real)
->2          a = extfun (8)
  3          PRINT a

   .
   .
   .
  63   100   FUNCTION REAL extfun (a)
             extfun = a * 3
             END FUNCTION
```

The STEP/INTO command is useful for examining external functions. However, if you use this command to stop execution at an internal subroutine or a DEF, the debugger steps into Run-Time Library (RTL) routines, providing you with no useful information. For example, in the following partial program, the debugger has suspended execution at source line 8. If you now enter a STEP/INTO command, the debugger steps into the relevant RTL code and informs you that no source lines are available.

```
  1  10   RANDOMIZE
    .
    .
    .
->8       GOSUB Print_routine
  9       STOP
    .
    .
    .
 20      Print_routine:
 21          IF Competition = Done
 22            THEN PRINT "The winning ticket is #";Winning_ticket
 23            ELSE PRINT "The game goes on."
 24          END IF
 25      RETURN
```

As in the previous example, a STEP command alone will cause the debugger to proceed directly to source line 9. To examine the source code of subroutines or DEF functions, you should use the SET BREAK command. The SET BREAK command is described in Section 5.3.5.3. In this case, a breakpoint set at the label *Print_routine* allows you to examine the subroutine beginning at source line 20.

5.3.7 Controlling Symbol References

In most cases, the way the debugger handles symbols is transparent to you. However, the following areas may require action on your part:

- Module setting
- Multiply-defined symbols

NOTE

When using the VMS Debugger, all VAX BASIC variable and label names within a single program unit must be unique; otherwise, the debugger will be unable to determine which symbol you are referring to.

5.3.7.1 Module Setting

To facilitate symbol searches, the debugger loads symbol records from the executable image into a run-time symbol table (RST), where they can be accessed efficiently. Unless a symbol record is in the RST, the debugger cannot recognize or properly interpret that symbol.

Because the RST takes up memory, the debugger loads it dynamically, anticipating what symbols you might want to reference in the course of execution. The loading process is called *module setting*, because all of the symbol records of a given module are loaded into the RST at one time.

At debugger startup, only the module containing the image transfer address is set. As your program executes, whenever the debugger interrupts execution it sets the module surrounding the current PC location. This lets you reference the symbols that should be visible at the current PC location.

If you try to reference a symbol in a module that has not been set, the debugger will warn you that the symbol is not in the RST. For example:

```
DBG> EXAMINE K
%DEBUG-W-NOSYMBOL, symbol 'K' is not in symbol table
DBG>
```

You must then use the SET MODULE command to set the module containing that symbol manually:

```
DBG> SET MODULE MOD3
DBG> EXAMINE K
MOD3\ROUT2\K: 26
DBG>
```

The SHOW MODULE command lists the modules of your program and identifies which modules have been set.

Note that dynamic module setting may slow the debugger down as more and more modules are set. If performance becomes a problem, you can use the CANCEL MODULE command to reduce the number of set modules, or you can disable dynamic module setting by issuing the SET MODE NODYNAMIC command. (The SET MODE DYNAMIC command enables dynamic module setting.)

5.3.7.2 Resolving Multiply-Defined Symbols

The debugger finds the symbols that you reference in commands according to the scope and visibility rules of the currently set language. In general, the debugger first looks for a symbol within the block or routine surrounding the current PC location; if the symbol is not found in that scope region, the debugger searches the nesting program unit, then its nesting unit, and so on. (The precise manner depends on the currently set language and guarantees that the proper declaration of a multiply-defined symbol is selected.)

The debugger must let you reference symbols throughout your program, not just those that are visible at the current PC location, to allow you to set breakpoints in arbitrary areas or examine arbitrary variables, and so on. Therefore, if the symbol is not visible at the current PC location, the debugger also searches other scope regions. First, it looks within the currently executing routine, then the caller of that routine, then its caller, and so on until the symbol is found. Symbolically, this search list is denoted *0,1,2, . . . ,n*, where *n* is the number of calls in the call stack. Within each of these scope regions, the debugger uses the visibility rules of the language to locate symbols.

If the debugger cannot resolve an ambiguity, it issues an error message. For example:

```
DBG>  EXAMINE Y
%DEBUG-W-NOUNIQUE, symbol 'Y' is not unique
DBG>
```

In that case, you can use a path-name prefix to uniquely specify a declaration of the given symbol. First, use the SHOW SYMBOL command to identify all path names associated with the given symbol; then use the desired path name when referencing the symbol. For example:

```
DBG>  SHOW SYMBOL Y
data MOD7\ROUT3\BLOCK1\Y
data MOD4\ROUT2\Y
DBG>  EXAMINE MOD4\ROUT2\Y
MOD4\ROUT2\Y: 12
DBG>
```

If you need to refer to a particular declaration of Y repeatedly, use the SET SCOPE command to establish a new default scope for symbol lookup. Then, references to Y without a path-name prefix will specify the declaration of Y that is visible in the new scope region. For example:

```
DBG>  SET SCOPE MOD4\ROUT2
DBG>  EXAMINE Y
MOD4\ROUT2\Y: 12
DBG>
```

To display the current scope for symbol lookup, use the SHOW SCOPE command. To restore the default scope, use the CANCEL SCOPE command.

5.4 A Sample Debugging Session

This section shows a sample debugging session using a VAX BASIC program that contains a logic error.

The following program compiles and links without diagnostic messages from either the compiler or the linker. However, after printing the headers, the program is caught in a loop printing the same figures indefinitely. For purposes of illustration, this example deals with the error as though it were not obvious.

Example

```
10 !SAMPLE program for DEBUG illustration
   DECLARE INTEGER Number
   Print_headers:
   PRINT "NUMBER", "SQUARE", "SQUARE ROOT"
   PRINT
   Print_loop:
   FOR Number = 10 TO 1 STEP -1
     PRINT Number, Number^2, SQR(Number)
     Number = Number + 1
   NEXT Number
   PRINT
   END
```

The following text shows the terminal dialogue for a debugging session which helps locate the error in program SAMPLE. The circled numbers are keyed to the explanatory notes that follow the dialogue.

```
$ BASIC/LIST/DEBUG SAMPLE ❶
$ LINK/DEBUG SAMPLE ❷
$ RUN SAMPLE

             VAX DEBUG Version 4.n
```

```
%DEBUG-I-INITIAL, language is BASIC module set to 'SAMPLE$MAIN' ❸
DBG> STEP 2 ❹
NUMBER          SQUARE        SQUARE ROOT
stepped to SAMPLE$MAIN\%line 7
     7:         FOR Number = 10 TO 1 STEP -1 ❺
DBG>  STEP 4 ❻
10        100          3.16228
stepped to  SAMPLE$MAIN\%LINE 7
     7:         FOR Number = 10 TO 1 STEP -1
DBG>  EXAMINE Number ❼
SAMPLE$MAIN\NUMBER:     10 ❽
DBG>  STEP 4 ❾
10        100          3.16228
stepped to  SAMPLE$MAIN\%LINE 7
     7:         FOR Number = 10 TO 1 STEP -1
DBG>  EXAMINE Number ❿
SAMPLE$MAIN\NUMBER:     10 ⓫
DBG>  DEPOSIT Number = 9 ⓬
DBG>  STEP 4 ⓭
9         81           3
stepped to  SAMPLE$MAIN\%LINE 7
     7:         FOR Number = 10 TO 1 STEP -1
DBG>  EXAMINE Number ⓮
SAMPLE$MAIN\NUMBER:     9 ⓯
DBG>  STEP ⓰
9         81           3
stepped to  SAMPLE$MAIN\%LINE 8
     8:            PRINT Number, Number^2, SQR(Number) ⓱
DBG>  STEP ⓲
stepped to SAMPLE$MAIN\%LINE 9
     9:         Number = Number + 1 ⓳
DBG>  EXIT ⓴
```

❶ Compile SAMPLE.BAS with the /LIST and /DEBUG qualifiers. The listing file may be useful while you are in the debugging session.

❷ Link SAMPLE.BAS with the /DEBUG qualifier.

❸ The debugger identifies itself and displays the debugger prompt after you invoke the debugger with the RUN command.

❹ Step through 2 executable statements to the FOR statement.

❺ The headers print successfully and the program reaches the FOR statement.

❻ Step through one iteration of the loop.

❼ Request the contents of the variable *Number*.

❽ The debugger shows the contents of the loop index to be 10.

❾ Step through another iteration of the loop.

❿ Examine the value of the loop index again.

⓫ The debugger shows that the loop index is still 10. The loop index has not changed from its initial setting in the FOR statement.

⓬ Deposit the correct value into *Number*.

⓭ Step through another iteration of the loop.

⓮ Examine the contents of *Number* again.

⓯ Observe that the number has not been changed yet.

⓰ Step through just one statement to discover what is interfering with the value of *Number* during execution of the loop.

⓱ Observe that this statement does not affect the value of *Number*.

⓲ Step through another statement in the loop.

⓳ Observe that this statement counteracts the change in the loop index.

⓴ Exit from the debugger. You can now edit the program to delete line 9 and reprocess the program. Alternatively, you could use the EDIT command while in the debugger environment.

This debugging session shows that the FOR...NEXT loop index (*Number*) is not being changed correctly. An examination of the statements in the loop shows that the variable *Number* is being decreased by one during each execution of the FOR statement, but incremented by one with each execution of the loop statements. From this you can determine that the loop index will not change at all and the program will loop indefinitely. To correct the problem, you must delete the incorrect statement and recompile the source program.

5.5 Debugger Command Summary

Table 5–1 lists all of the debugger commands and any related DCL commands in functional groupings, along with brief descriptions.

During a debugging session, you can get online HELP on any command and its qualifiers by typing the HELP command followed by the name of the command in question, in this format:

```
HELP command
```

Table 5–1: Debugger Command Summary

Command	Description
Starting and Ending a Debugging Session	
RUN[1]	Invokes the debugger if LINK/DEBUG was used
RUN/[NO]DEBUG[1]	Controls whether the debugger is invoked when the program is executed
CTRL/Z or EXIT	Ends a debugging session, executing all exit handlers
QUIT	Ends a debugging session without executing any exit handlers declared in the program
CTRL/C	Aborts program execution or a debugger command without interrupting the debugging session
{ SET / SHOW } ABORT_KEY	Assigns the default CTRL/C abort function to another CTRL/key sequence; identifies the CTRL/key sequence currently defined for the abort function
CTRL/Y/DEBUG[1]	Interrupts a program that is running without debugger control and invokes the debugger
ATTACH	Passes control of your terminal from the current process to another process
SPAWN	Creates a subprocess, enabling you to execute DCL commands without ending a debugging session or losing your debugging context
Controlling and Monitoring Program Execution	
GO	Starts or resumes program execution
STEP	Executes the program up to the next line, instruction, or specified instruction
{ SET / SHOW } STEP	Establishes or displays the default qualifiers for the STEP command
{ SET / SHOW / CANCEL } BREAK	Sets, displays, or cancels breakpoints

[1]This is a DCL command, not a debugger command.

(continued on next page)

Table 5–1 (Cont.): Debugger Command Summary

Command	Description
Controlling and Monitoring Program Execution	
{SET, SHOW, CANCEL} TRACE	Sets, displays, or cancels tracepoints
{SET, SHOW, CANCEL} WATCH	Sets, displays, or cancels watchpoints
SHOW CALLS	Identifies the currently active routine calls
SHOW STACK	Gives additional information about the currently active routine calls
CALL	Calls a routine
Examining and Manipulating Data	
EXAMINE	Displays the value of a variable or the contents of a program location
SET MODE [NO]OPERANDS	Controls whether the address and contents of the instruction operands are displayed when you examine an instruction
DEPOSIT	Changes the value of a variable or the contents of a program location
EVALUATE	Evaluates a language or an address expression
Controlling Type Selection	
{SET, SHOW, CANCEL} RADIX	Establishes the radix for data entry and display, displays the radix, or restores the radix
{SET, SHOW, CANCEL} TYPE	Establishes the type for program locations that are not associated with a compiler-generated type, displays the type, or restores the type
SET MODE [NO]G_FLOAT	Controls whether double-precision, floating-point constants are interpreted as G_FLOAT or D_FLOAT

(continued on next page)

Table 5–1 (Cont.): Debugger Command Summary

Command	Description
Controlling Symbol Lookup and Symbolization	
SHOW SYMBOL	Displays symbols in your program
$\left\{\begin{array}{l}\text{SET}\\\text{SHOW}\\\text{CANCEL}\end{array}\right\}$ MODULE	Sets a module by loading its symbol records into the debugger's symbol table, identifies a set module, or cancels a set module
$\left\{\begin{array}{l}\text{SET}\\\text{SHOW}\\\text{CANCEL}\end{array}\right\}$ IMAGE	Sets a shareable image by loading data structures into the debugger's symbol table, identifies a set image, or cancels a set image
SET MODE [NO]DYNAMIC	Controls whether modules and shareable images are set automatically when the debugger interrupts execution
$\left\{\begin{array}{l}\text{SET}\\\text{SHOW}\\\text{CANCEL}\end{array}\right\}$ SCOPE	Establishes, displays, or restores the scope for symbol lookup
SYMBOLIZE	Converts a virtual address to a symbolic address
SET MODE [NO]LINE	Controls whether program locations are displayed in terms of line numbers or routine-name + byte offset
SET MODE [NO]SYMBOLIC	Controls whether program locations are displayed symbolically or in terms of numeric addresses
Displaying Source Code	
TYPE	Displays lines of source code
EXAMINE/SOURCE	Displays the source code at the location specified by the address expression
SEARCH	Searches the source code for the specified string
$\left\{\begin{array}{l}\text{SET}\\\text{SHOW}\end{array}\right\}$ SEARCH	Establishes or displays the default qualifiers for the SEARCH command
SET STEP [NO]SOURCE	Enables or disables the display of source code after a STEP command has been executed or at a breakpoint, tracepoint, or watchpoint
$\left\{\begin{array}{l}\text{SET}\\\text{SHOW}\end{array}\right\}$ MARGINS	Establishes or displays the left and right margin settings for displaying source code

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Table 5–1 (Cont.): Debugger Command Summary

Command	Description
	Displaying Source Code
{ SET / SHOW / CANCEL } SOURCE	Creates, displays, or cancels a source directory search list
{ SET / SHOW } MAX_SOURCE_FILES	Establishes or displays the maximum number of source files that can be kept open at one time
	Using Screen Mode
SET MODE [NO]SCREEN	Enables or disables screen mode
DISPLAY	Creates or modifies a display
SCROLL	Scrolls a display
EXPAND	Expands or contracts a display
MOVE	Moves a display across the screen
{ SHOW / CANCEL } DISPLAY	Identifies or deletes a display
{ SET / SHOW / CANCEL } WINDOW	Creates, identifies, or deletes a window definition
SELECT	Selects a display for a display attribute
SHOW SELECT	Identifies the displays selected for each of the display attributes
SAVE	Saves the current contents of a display and writes it to another display
EXTRACT	Saves a display or the current screen state and writes it to a file
{ SET / SHOW } TERMINAL	Establishes or displays the height and width of the screen
SET MODE [NO]SCROLL	Controls whether an output display is updated line by line or once per command
CTRL/W or DISPLAY/REFRESH	Refreshes the screen

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Table 5–1 (Cont.): Debugger Command Summary

Command	Description
	Editing Source Code
EDIT	Invokes an editor during a debugging session
{ SET / SHOW } EDITOR	Establishes or identifies the editor invoked by the EDIT command
	Defining Symbols
DEFINE	Defines a symbol as an address, command, or value
DELETE	Deletes symbol definitions
{ SET / SHOW } DEFINE	Establishes or displays the default qualifier for the DEFINE command
SHOW SYMBOL/DEFINED	Identifies symbols that have been defined with the DEFINE command
	Using Keypad Mode
SET MODE [NO]KEYPAD	Enables or disables keypad mode
DEFINE/KEY	Creates key definitions
DELETE/KEY	Deletes key definitions
SET KEY	Establishes the key definition state
SHOW KEY	Displays key definitions
	Using Command Procedures and Log Files
@file-spec	Executes a command procedure
{ SET / SHOW } ATSIGN	Establishes or displays the default file specification that the debugger uses to search for command procedures
DECLARE	Defines parameters to be passed to command procedures
{ SET / SHOW } LOG	Specifies or identifies the debugger log file
SET OUTPUT [NO]LOG	Controls whether a debugging session is logged

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Table 5–1 (Cont.): Debugger Command Summary

Command	Description
Using Command Procedures and Log Files	
SET OUTPUT [NO]SCREEN_LOG	Controls whether, in screen mode, the screen contents are logged as the screen is updated
SET OUTPUT [NO]VERIFY	Controls whether debugger commands are displayed as a command procedure is executed
SHOW OUTPUT	Displays the current output options established by the SET OUTPUT command
Using Control Structures	
FOR	Executes a list of commands while incrementing a variable
IF	Executes a list of commands conditionally
REPEAT	Executes a list of commands a specified number of times
WHILE	Executes a list of commands while a condition is true
EXITLOOP	Exits an enclosing WHILE, REPEAT, or FOR loop
Debugging Multiprocess Programs	
CONNECT	Brings a process under debugger control
DEFINE/PROCESS_GROUP	Assigns a symbolic name to a list of process specifications
DO	Executes commands in the context of one or more processes
SET MODE [NO]INTERRUPT	Controls whether execution is interrupted in other processes when it is suspended in some process
$\left\{\begin{matrix}\text{SET}\\\text{SHOW}\end{matrix}\right\}$ PROCESS	Modifies the multiprocess debugging environment or displays process information

(continued on next page)

Table 5–1 (Cont.): Debugger Command Summary

Command	Description
	Additional Commands
{DISABLE, ENABLE, SHOW} AST	Disables the delivery of ASTs in the program, enables the delivery of ASTs, or identifies whether delivery is enabled or disabled
{SET, SHOW} EVENT_FACILITY	Establishes or identifies the current run-time facility for language-specific events
{SET, SHOW} LANGUAGE	Establishes or displays the current language
SET MODE [NO]SEPARATE	Controls whether the debugger, when used on a workstation running VMS, creates a separate window for debugger input and output
SET OUTPUT [NO]TERMINAL	Controls whether debugger output, except for diagnostic messages, is displayed or suppressed
SET PROMPT	Specifies the debugger prompt
{SET, SHOW} TASK	Modifies the tasking environment or displays task information
SHOW EXIT_HANDLERS	Identifies the exit handlers declared in the program
SHOW MODE	Identifies the current debugger modes established by the SET MODE command (for example, screen mode, step mode)
SHOW OUTPUT	Identifies the current output options established by the SET OUTPUT command

Part II
VAX BASIC Programming Concepts

Chapter 6

Getting Started with VAX BASIC

A VAX BASIC program is a series of instructions for the VAX BASIC compiler. These instructions, no matter how varied, are all built using the same fundamental elements of VAX BASIC. This chapter describes the elements or building blocks of VAX BASIC.

6.1 Line Numbers

Traditionally, BASIC programs consisted of statements preceded by unique line numbers. However, VAX BASIC gives you the option of developing programs with traditional line numbers or programs with no line numbers at all.

6.1.1 Programs with Line Numbers

If you use line numbers in your programs, you must follow these rules:

- A line number must be a unique integer between 1 and 32767 (if your program has duplicate line numbers, the last line with that number replaces the previous one).
- A line number must begin in the first character position on the line.
- A line number can contain leading zeros; however, embedded spaces, tabs, and commas are invalid in line numbers.
- There must be a line number on the first line of the program.
- If a source file contains subprograms, then each subprogram must begin on a numbered line.
- The line number of a subprogram must be greater than that of any preceding subprogram line number.

- Text following an END, END SUB, or END FUNCTION statement must begin on a numbered line.

Note, that, in a multiple-unit program with line numbers, any comments following an END, END SUB, or END FUNCTION statement become a part of the previous subprogram during compilation unless they begin on a numbered line. This is not the case in multiple-unit programs without line numbers.

Although line numbers are not required, you may want to use them on every line that can cause a run-time error, depending on the type of error handling you use. See Chapter 17 for more information about handling run-time errors.

6.1.2 Programs Without Line Numbers

If you do not use line numbers in your programs, you must follow these rules:

- Use a text editor to enter and edit the program; you cannot enter programs without line numbers directly in the environment.
- No line numbers are allowed anywhere in the program module.
- The ERL function is not allowed.
- Do not use the RESUME statement with a line number as a target.
- REM statements are not allowed.
- If a source file contains subprograms, any text following an END, END SUB, or END FUNCTION statement must begin on a new physical line.
- Other files cannot be appended, because appended files must contain at least one line number.

Note that, in a multiple-unit program without line numbers, any comments following an END, END SUB, or END FUNCTION statement become a part of the next subprogram during compilation (unless there is no next subprogram). This is not the case in multiple-unit programs with line numbers.

Note that you can avoid all of these restrictions by placing a line number on the first line of your program; no additional line numbers are required. The line number on the first program line causes the VAX BASIC compiler to compile your program as a program with line numbers.

When you enter a program with or without line numbers, you can begin your program statements in the first character position on a line. While these statements would be considered immediate mode statements if entered in the BASIC environment, they are valid in a program that is created with a text editor.

For example, you can enter the following program directly into the environment:

Example

```
10 !This is a short program that you can enter
   !and run in the BASIC environment
   !
   PRINT "This program will convert pound weight to kilograms"
   INPUT "How many pounds";A
   !Here is the conversion step
   B = A * 2.2
   PRINT "For ";A;" pounds, the kilogram weight is ";B
   END
```

Output

```
This program will convert pound weight to kilograms
How many pounds? 10
For  10  pounds, the kilogram weight is  22
```

In order to develop the following program, you have to use a text editor, and you must observe the restrictions previously listed.

Example

```
!This is a short program that does not contain any
!VAX BASIC line numbers.
!This program must be entered using a text editor;
!it cannot be entered directly into the environment.
!
PRINT "This program converts kilogram weight to pounds"
INPUT "How many kilograms";A
!This is the conversion factor
B = A / 2.2
PRINT "For ";A;" kilograms, the pound weight is ";B
END
```

Output

```
This program converts kilogram weight to pounds
How many kilograms? 11
For  11  kilograms, the pound weight is  5
```

Note that you can use exclamation comment fields instead of REM statements to insert comments into programs without line numbers. An exclamation point in column 1 in the environment causes the VAX BASIC compiler to ignore the rest of the line. You can also identify program statements in programs without line numbers by using labels.

6.1.3 Labels

A label is a 1- to 31-character identifier that you use to identify a block of statements. All label names must begin with a letter; the remaining characters, if any, can be any combination of letters, digits, dollar signs ($), underscores (_), or periods (.).

Labels have two advantages over line numbers:

- Meaningful label names provide documentation.
- You can use labels in programs with or without line numbers.

When you use a label to mark a program location, you must end the label with a colon (:). The colon is used to show that the label name is being defined instead of referenced. When you reference the label, do not include the colon. In the following example, the label names end with colons when they mark a location, but the colons are not present when the labels are referenced.

Example

```
OPTION TYPE = EXPLICIT          ! Require declarations
DECLARE INTEGER A
   .
   .
   .
Outer_decision:
      IF A <> B
      THEN
Inner_decision:
      IF B = C
        THEN
          A = A + 1
          GOTO Outer_loop
        ELSE
          B = B + 1
          GOTO Inner_loop
        END IF
      END IF
```

Labels have no effect on the order in which program lines are executed; they are used to identify a statement or block of statements.

6.1.4 Continuation of Long Program Statements

If a program line is too long for one line of text, you can continue the program line by typing an ampersand (&) and pressing the RETURN key at the end of the line. Note that only spaces and tabs are valid between the ampersand and the carriage return.

A single statement that spans several text lines requires an ampersand at the end of each continued line. For example:

```
OPEN "SAMPLE.DAT" AS FILE #2%,          &
      SEQUENTIAL VARIABLE,              &
      RECORDSIZE 80%
```

In an IF...THEN...ELSE construction, statement separators are not necessary. If a continuation line begins with THEN or ELSE, then no statement separator is necessary. Similarly, in a line following a THEN or an ELSE, there is no statement separator.

Example

```
IF (A$ = B$)
THEN
   PRINT "The two values are equal"
ELSE
   PRINT "The two values are different"
END IF
```

Several statements can be associated with a single program line. If there are several statements on one line, they must be separated by backslashes (\ ). For example:

```
PRINT A \ PRINT V \ PRINT G
```

Because all statements are on the same program line, any reference to this program line refers to all three statements. In the preceding example, VAX BASIC cannot execute just one of the statements without executing the other two.

6.2 Identifying Program Units

You can delimit a main program compilation unit with the PROGRAM and END PROGRAM statements. This allows you to identify a program with a name other than the file name. The program name must not duplicate the name of a SUB, FUNCTION, or PICTURE subprogram. For example:

```
PROGRAM Sort_out
    .
    .
    .
END PROGRAM
```

If you include the PROGRAM statement in your program, the name you specify becomes the module name of the compiled source. This feature is useful when you use object libraries because the librarian stores modules by their module name rather than the file name. Similarly, module names are used by the VMS Debugger and the VMS Linker.

For more information about PROGRAM units, see Chapter 14.

6.3 The VAX BASIC Character Set

VAX BASIC uses the full ASCII character set, which includes the following:

- The letters A through Z, both upper- and lowercase
- The digits 0 through 9
- Special characters

See the *VAX BASIC Reference Manual* for a complete list of the ASCII character set and character values.

The VAX BASIC compiler does not distinguish between upper- and lowercase letters, except letters inside quotation marks (called *string literals*) or letters in a DATA statement. The compiler also does not process characters in a REM statement or comment field.

You can use nonprinting characters in your program, for example, in string literals and constants, but to do so you must do one of the following:

- Use a predefined constant such as ESC or DEL
- Use the CHR$ function to specify an ASCII value

See Section 6.6 for more information on predefined constants. See Chapter 12 for more information on the CHR$ function.

6.4 Program Documentation

Documenting a program is the process of mixing text (comments) and code in a way that helps make the program more understandable. Program documentation does not affect the way a program executes.

You can sprinkle comments liberally throughout a program; however, programs that are neatly structured need fewer comments. You can clarify your code by

- Using meaningful variable names
- Including sufficient white space
- Indenting your program lines according to the structure of your code

In VAX BASIC, a comment field starts with an exclamation point (!) and ends with a carriage return. The following example contains both comments and program statements. VAX BASIC ignores any text that follows an exclamation point.

Example

```
PROGRAM sample
!+
!   Require that all variables be declared
!-
OPTION TYPE = EXPLICIT
!+
!   Set up error handler
!-
WHEN ERROR USE Error_routine
!+
!   Declarations
!-
    .
    .
    .
END PROGRAM
```

You can also mix comments and code on the same line.

Example

```
DECLARE                                                &
    INTEGER                                            &
    Print_page,         ! Current page number          &
    Print_line,         ! Current line number          &
    Print_column        ! Current column number
```

In this case, VAX BASIC ignores all text between the exclamation point and the carriage return, with one exception: VAX BASIC still recognizes the ampersand. This is a continuation character that specifies that a single statement is being continued on the next line. Only spaces and tabs are valid between the ampersand and the carriage return.

NOTE

You can also terminate a comment field with an exclamation point. However, because VAX BASIC treats any text that follows

the second exclamation point as part of your program code, this practice is not recommended.

6.5 Declarations and Data Types

VAX BASIC offers two different methods for creating variables and specifying their data types:

- Implicit data typing
- Explicit data typing

With implicit data typing, VAX BASIC creates and specifies a data type for a variable the first time you reference it in your program. With explicit data typing, you must use one of four declarative statements to name and type your program values.

VAX BASIC has five data types:

- Integer (INTEGER)
- Floating-point (REAL)
- String (STRING)
- Packed Decimal (DECIMAL)
- Record File Address (RFA)

Within the INTEGER and REAL data types there are further subdivisions: BYTE, WORD, or LONG for INTEGER and SINGLE, DOUBLE, GFLOAT, or HFLOAT for REAL. Choosing one of these *subtypes* lets you control two things:

- The amount of storage required for the value; its "container size"
- The range and precision that the value can accept

For more information about data types, see Chapter 9.

6.5.1 Implicit Data Typing

With implicit data typing, VAX BASIC creates and specifies a data type for a variable the first time you reference it. You specify the data type of the variable by a suffix on the variable name:

- A percent sign suffix (%) specifies the INTEGER data type.
- A dollar sign suffix ($) specifies the STRING data type.

- Any other ending character specifies a variable of the default data type.

The VAX BASIC default data type is SINGLE; however, you can specify your own default at DCL command level, inside the BASIC environment, or with the OPTION statement in your program. For more information on establishing default data types, see Chapters 3 and 4 and the OPTION statement in the *VAX BASIC Reference Manual.*

The first time VAX BASIC references one of these variables, it creates a variable with that name and data type and allocates storage for that variable.

In the following example, VAX BASIC creates two INTEGER variables, *A%* and *B%*. Even though the values assigned to these variables are REAL, VAX BASIC converts these values to INTEGER to match the data type specified for the variables. The sum of these two values is therefore 30, not 30.6 as it would be if the variables were named simply *A* and *B*.

Example

```
A% = 10.1
B% = 20.5
PRINT A% + B%
```

Output

```
 30
```

With explicit data typing, you use a declarative statement to name and specify a data type for your program values.

6.5.2 Explicit Data Typing

VAX BASIC has four declarative statements. These statements create variables and allocate storage. The statements are:

- DECLARE
- DIMENSION
- COMMON
- MAP

The statement you choose depends on the way in which you will use the variables:

- DECLARE and DIMENSION allocate dynamic storage for variables; storage is allocated when the program executes.

- COMMON and MAP statements allocate storage for variables statically; storage is allocated when the program is compiled.

The difference between these types of storage is most apparent in the case of strings; string variables created with DECLARE can change their length during program execution, while those created with MAP and COMMON remain fixed in length. All four declarative statements associate a data type with a variable. For more information, see Chapter 9.

6.6 Constants

A constant is a value that does not change during program execution. Constants can be either literals or named constants, and can be of any data type except RFA. You can use the DECLARE CONSTANT statement to create named constants. Constants can be of the following types:

- Integer
- Floating-point
- String

In addition, VAX BASIC provides predefined constants that are useful for:

- Formatting program output to improve clarity
- Making source code easier to understand
- Using nonprinting characters without having to look up their ASCII values

Table 6–1 lists all of the VAX BASIC predefined constants.

Table 6–1: Predefined Constants

Constant	Decimal ASCII Value	Purpose
BEL (Bell)	7	Sounds the terminal bell
BS (Backspace)	8	Moves cursor one position to the left
HT (Horizontal Tab)	9	Moves cursor to the next horizontal tab stop
LF (Line Feed)	10	Moves cursor to the next line

(continued on next page)

Table 6–1 (Cont.): Predefined Constants

Constant	Decimal ASCII Value	Purpose
VT (Vertical Tab)	11	Moves cursor to the next vertical tab stop
FF (Form Feed)	12	Moves cursor to the start of the next page
CR (Carriage Return)	13	Moves cursor to the beginning of the current line
SO (Shift Out)	14	Shifts out for communications networking, screen formatting, and alternate graphics
SI (Shift In)	15	Shifts in for communications networking, screen formatting, and alternate graphics
ESC (Escape)	27	Marks the beginning of an escape sequence
SP (Space)	32	Inserts one blank space in program output
DEL (Delete)	127	Deletes the last character entered
PI	None	Represents the number PI with the precision of the default floating-point data type

These predefined constants simplify the task of using nonprinting characters in your programs. For example, the following statement causes a bell to sound on your terminal:

```
PRINT BEL
```

The following statement prints and underlines a word on a hardcopy terminal:

```
PRINT "NAME:" + BS + BS + BS + BS + BS + "_____"
```

To print and underline the same word on a VT100 series video display terminal, use the following statement. Note that the "m" in the following example must be lowercase:

```
PRINT ESC + "[4mNAME:" + ESC + "[0m"
```

You can also create your own predefined constants with the DECLARE CONSTANT statement. The following statements define and print a constant that prints and underlines the string "NAME:":

```
DECLARE STRING CONSTANT Underlined_word = ESC + "[4mNAME:" + ESC + "[0m"
PRINT Underlined_word
```

For more information on constants, see Chapter 9 and the *VAX BASIC Reference Manual*.

6.7 Variables

A variable is a unique storage location that is referred to by a variable name. The most important property of variables is that their values can change during program execution. Each named location can hold only one value at a time.

A variable name can have up to 31 characters. The name must begin with a letter; the remaining characters, if any, can be any combination of letters, digits, dollar signs ($), underscores (_), and periods (.).

Variables can be grouped in an orderly series under a single name. These groups are called *arrays*. You refer to a single variable in an array by using one or more *subscripts* that specify the variable's position in the array.

6.7.1 Floating-Point Variables

A floating-point variable is a named location that stores a single floating-point value. The storage space required to hold the value depends on the variable's REAL subtype. For example, each SINGLE floating-point variable requires 32 bits (4 bytes) of storage, while each DOUBLE floating-point variable requires 64 bits (8 bytes) of storage.

Note that if any integer value is assigned to a floating-point variable, VAX BASIC converts the value to a floating-point number.

6.7.2 Integer Variables

An integer variable is a named location that stores a whole number. The storage space required to hold the value depends on the variable's INTEGER subtype. For example, each BYTE integer variable requires 8 bits (1 byte) of storage, while each LONG integer variable requires 32 bits (4 bytes) of storage.

If you assign a floating-point value to an integer variable, VAX BASIC truncates the fractional portion of the value; it does not round to the nearest integer. In the following example, VAX BASIC assigns the value –5 to the integer variable, not –6.

```
B% = --5.7
```

Although the integer data types LONG, WORD, and BYTE allow the minimum values –2147483648, –32768, and –128 respectively, you cannot use these constants explicitly, because VAX BASIC reports an integer overflow error while attempting to parse the literal constant. To use these values, you must use either radix notation, such as –"32768"L, or a constant expression. For example:

```
DECLARE WORD CONSTANT Word_const = -32767 - 1
```

6.7.3 Packed Decimal Variables

A packed decimal (DECIMAL data type) variable is made up of several storage locations, the number of which depends on the declared size of the variable. However, a packed decimal variable is still referred to by a single variable name.

When you declare a packed decimal variable, you specify the total number of digits and the number of digits to the right of the decimal place that you want.

The following statement creates a packed decimal variable named *My_decimal*, which can contain up to eight digits: six digits to the left of the decimal point, and two digits to the right of the decimal point.

```
OPTION TYPE = EXPLICIT

DECLARE DECIMAL (8,2) My_decimal
```

Packed decimal numbers are most useful for dollars-and-cents calculations.

6.7.4 String Variables

Unlike some of the numeric variables described so far, a string variable does not correspond to a single location in memory because a string variable is more likely to exceed a single location in memory. Therefore, the value of a string variable may be contained in any number of memory locations. However, a string variable is still referred to by a single name. For example:

```
DECLARE STRING Employee_name
```

6.7.5 Subscripted Variables

A subscripted variable is a floating-point, integer, packed decimal, RFA, or string variable that is part of an array. Chapter 8 describes arrays in detail.

An array is a set of data organized in one or more dimensions. A one-dimensional array is called a *list* or *vector*. A two-dimensional array is called a *matrix*. VAX BASIC arrays can have up to 32 dimensions.

When you create an array, its size is determined by the number of dimensions and the maximum size, called the *bound*, of each dimension. Subscripts begin by default with 0, not 1. That is, when calculating the number of elements in a dimension, you count from zero to the bound specified.

The following DECLARE statement creates an 11 by 11 array of integers (11 by 11 rather than 10 by 10, because VAX BASIC arrays are zero-based by default). Therefore, the array contains a total of 121 array elements.

```
DECLARE INTEGER My_array (10, 10)
```

There are many applications where you need to reference data for a particular range of values. In order to do this, VAX BASIC lets you specify a lower bound other than zero for your arrays. The following example declares an array containing the birth rates for the years between 1945 and 1985:

```
OPTION TYPE = EXPLICIT,         &
       SIZE = REAL SINGLE

DECLARE REAL Birth_rates(1945 TO 1985)
```

Subscripts define the position of an element in an array; the expression *Birth_rates*(1970) refers to the 26th value (represented by 1970) of the array *Birth_rates*. For more information on arrays, see Chapter 8.

NOTE

> By default, the compiler signals an error if a subscript is larger than the allowable range. Also, the amount of storage that the system can allocate depends on available memory. Therefore, very large arrays may cause an internal allocation error.

VAX BASIC sets variables to zero or null values at the start of program execution; that is, it *initializes* them. Variables initialized by VAX BASIC include the following:

- Numeric variables and array elements (except those in MAP or COMMON statements).

- String variables and array elements (except those in MAP or COMMON statements).
- Variables in subprograms. Subprogram variables (except those in MAP or COMMON statements) are initialized to zero or the null string each time the subprogram is called.
- Arrays created with an executable DIMENSION statement. VAX BASIC reinitializes the array each time the array is redimensioned.

6.8 Keywords and Reserved Words

Keywords are elements of the VAX BASIC language. Keywords that are not reserved can be used as user identifiers such as labels, variable or constant names, or names of MAP or COMMON areas. Depending upon the location of the keyword in your program statement, the compiler will treat it as either a keyword or a user identifier. Your VAX BASIC programs use keywords and reserved words to:

- Define data
- Perform operations
- Invoke functions

See the *VAX BASIC Reference Manual* for a list of VAX BASIC keywords and reserved words.

Keywords determine whether the statement is executable or nonexecutable. Executable statements such as PRINT, GOTO, and READ perform operations. Nonexecutable statements such as DATA, DECLARE, and REM, describe the characteristics and arrangement of data, usage information, and comments.

Every statement except LET and empty statements (lines that start with an exclamation point) must begin with a keyword. A VAX BASIC keyword cannot have embedded spaces or be split across lines of text. There must be a space or tab between the keyword and any other variables or operators.

There are also phrases of keywords. In this case, the spacing requirements vary.

6.9 Operands, Operators, and Expressions

An *operand* is anything that contains a value. An operand can be a scalar, a subscripted variable, a named constant, a literal, and so on. An *operator* specifies a procedure to be carried out by one or more operands. An *expression* consists of operands separated by operators.

VAX BASIC has four types of operators:

- Arithmetic
- String
- Relational
- Logical

When combined with operands, these operators can produce:

- Numeric expressions
- String expressions
- Conditional expressions

For more information about operands, operators, and expressions, see the *VAX BASIC Reference Manual.*

6.10 Assignment Statements

VAX BASIC has four statements that assign values to variables:

- LET
- INPUT
- LINPUT
- INPUT LINE

LET and INPUT statements allow you to assign values to any type of variable, while LINPUT and INPUT LINE allow you to assign values to string variables. For example:

```
LET A = 1.25
```

LET is an optional keyword. You can assign a value to more than one variable at a time, although this is not recommended. Instead, you should use a separate assignment statement each time you assign a value to a variable.

Whenever you assign a value to a numeric variable, VAX BASIC converts the value to the data type of the variable. If you assign a floating-point value to an integer variable, VAX BASIC truncates the value at the decimal point. If you assign an integer value to a floating-point variable, VAX BASIC converts the value to floating-point format.

You can also assign values to variables with the DATA and READ statements; however, this method requires that you know all input data values while you are coding your program.

The INPUT, LINPUT, and INPUT LINE statements all assign values in the context of data being read into the program. These statements are discussed in Chapter 7.

Chapter 7

Simple Input and Output

This chapter explains how to use the VAX BASIC statements that move data to and from your program.

7.1 Program Input

VAX BASIC programs receive data in three ways:

- You can enter data interactively while the program runs. You do this with the INPUT, INPUT LINE, and LINPUT statements.
- If you know all the information your program will require, you can enter it as you write the program. You do this with the READ, DATA, and RESTORE statements, or you can name constants with the known values.
- You can read data from files outside the program. You do this with the INPUT #, INPUT LINE #, and LINPUT # statements.

The following sections describe how to use these statements in detail.

7.1.1 Providing Input Interactively

The INPUT, INPUT LINE, and LINPUT statements prompt a user for data while the program runs.

7.1.1.1 The INPUT Statement

The INPUT statement interactively prompts the user for data. You can use the optional prompt string to clarify the input request by specifying the type and number of data elements required by the program. This is especially useful when the program contains many variables, or when someone else is running your program.

Example

```
INPUT "PLEASE TYPE 3 INTEGERS" ;B% ,C% ,D%
A% = B% + C% + D%
PRINT "THEIR SUM IS"; A%
END
```

Output

```
PLEASE TYPE 3 INTEGERS? 25,50,75 RET
THEIR SUM IS 150
```

When your program runs, VAX BASIC stops at each INPUT, LINPUT, or INPUT LINE statement, prints a string prompt, if specified, and an optional question mark (?) followed by a space; it then waits for your input. By using either a comma or semicolon, you can affect the format of your string prompt.

- If you have a semicolon separating the input prompt string from the variable, VAX BASIC prints the question mark and space immediately after the input prompt string.
- If you have a comma separating the input prompt string from the variable, VAX BASIC prints the input prompt string, skips to the next print zone, and then prints the question mark and space.

See Section 7.2.1 for more information about print zones. For more information on formatting string prompts, see Section 7.1.1.3.

You must provide one value for each variable in the INPUT request. If you do not provide enough values, VAX BASIC prompts you again.

Example

```
INPUT A,B
END
```

Output

```
? 5 RET
? 6 RET
```

VAX BASIC interprets a carriage return (null input) as a zero value for numeric variables and as a null string for string variables. For example:

```
? 5 RET
? RET
```

These responses assign the value 5 to variable *A* and zero to variable *B*. In contrast, if you provide more values than there are variables, VAX BASIC ignores the excess.

In the following example, VAX BASIC ignores the extra value (8). Note that you can type multiple values if you separate them with commas. Because commas separate variables in the PRINT statement, VAX BASIC prints each variable at the start of a print zone.

Example

```
INPUT A,B,C
PRINT A,B,C
END
```

Output

```
? 5,6,7,8 RET
 5             6             7
```

If you name a numeric variable in an INPUT statement, you must supply numeric data. If you supply string data to a numeric variable, VAX BASIC signals "Illegal number" (ERR=52). If you supply a floating-point number for an integer variable, VAX BASIC signals "Data format error" (ERR=50).

If you name a string variable in an INPUT statement, you can supply either numbers or letters, but VAX BASIC treats the data you supply as a string. Because digits and a decimal point are valid text characters, numbers can be interpreted as strings.

Example

```
INPUT "Please type a number"; A$
PRINT A$
```

Output

```
Please type a number? 25.5
25.5
```

VAX BASIC interprets the response as a four-character string instead of as a numeric value.

You can type strings with or without quotation marks. However, if you want to input a string containing a comma, you should enclose the string in quotation marks or use the INPUT LINE or LINPUT statement. If you do not, VAX BASIC treats the comma as a delimiter and assigns only part of the string to the variable. If you use quotation marks, be sure to type both beginning and ending marks. If you leave out the end quotation mark, VAX BASIC signals "Data format error" (ERR=50).

7.1.1.2 The INPUT LINE and LINPUT Statements

The INPUT LINE and LINPUT statements prompt you for string data while your program runs. You can respond with strings that contain commas, semicolons, and quotation marks, which are characters that the INPUT statement interprets as delimiters.

The INPUT LINE statement accepts and stores all characters, including quotation marks, semicolons, and commas, up to and including the line terminator or terminators. LINPUT accepts all characters up to, but not including, the line terminator or terminators.

In the following example, because both INPUT LINE and LINPUT treat your input as a string literal, VAX BASIC interprets quotation marks, commas, and semicolons as characters, not as string delimiters. When *A$* is input with the INPUT LINE statement, the carriage return line terminator is stored as part of the string. The first PRINT statement tells VAX BASIC to print all three variables on one line, starting each one in a new print zone. However, when VAX BASIC prints the three strings, it prints the carriage return character at the end of string *A$*; this terminates the current line and causes *B$* to begin on a new line.

Example

```
INPUT LINE A$
LINPUT B$
LINPUT C$
PRINT A$, B$, C$
PRINT "DONE"
END
```

Output

```
? SINGLE, DOUBLE RET
? "GFLOAT" RET
? HFLOAT; REAL Data Types RET

SINGLE, DOUBLE
"GFLOAT"     HFLOAT; REAL Data Types
DONE
```

The INPUT, INPUT LINE, and LINPUT statements can accept data from a terminal or a terminal-format file. See Section 7.3 for information on I/O to terminal-format files.

7.1.1.3 Enabling and Disabling the Question Mark Prompt

With the SET PROMPT statement, VAX BASIC allows you to enable and disable the question mark prompt.

By default, VAX BASIC displays the question mark prompt. For instance, the following example displays the default prompt string.

Example

```
INPUT "Please input 3 integer values";A%, B%, C%
```

Output

```
Please input 3 integer values?
```

You can, however, disable the question mark prompt by specifying the SET NO PROMPT statement.

Example

```
SET NO PROMPT
INPUT "Please input 3 integer values";A%, B%, C%
```

Output

```
Please input 3 integer values
```

When you disable the question mark prompt, you can specify your own prompt at the end of each prompt string. The following example inserts a colon at the end of the prompt string.

Example

```
SET NO PROMPT
INPUT "Please enter your name: ";Employee_name$
```

Output

```
Please enter your name:
```

Now, if the SET PROMPT statement is specified, VAX BASIC displays both the colon and a question mark.

Example

```
SET PROMPT
INPUT "Please enter your name: ";Employee_name$
```

Output

```
Please enter your name: ?
```

The SET [NO] PROMPT statement is valid for INPUT, LINPUT, INPUT LINE, and MAT INPUT statements. If the prompt is disabled, any one of the following commands reenables it:

- The SET PROMPT statement
- The CHAIN statement
- The NEW, OLD, RUN, or SCRATCH compiler command

7.1.2 Providing Input from the Source Program

The following sections describe the READ, DATA, and RESTORE statements. To use READ and DATA statements, you must know what data is required when writing the program. These statements do not stop to request data while the program runs. Therefore, your program runs faster than with the INPUT statements.

The RESTORE statement lets you use the same data items more than once.

7.1.2.1 The READ and DATA Statements

The READ statement reads values from a data block. A data pointer keeps track of the data read. Each time the READ statement requests data, VAX BASIC retrieves the next available constant from a DATA statement. The DATA statement contains the values that the READ statement reads. In a DATA statement, integer constants are whole numbers; they cannot be followed by a percent sign. In the following example, VAX BASIC signals an error because the integer constants in the DATA statement contain percent signs.

Example

```
10    WHEN ERROR USE catch_it
         DATA 1%, 2%, 3%
20       READ A%, B%, C%
      END WHEN
400   HANDLER catch_it
         PRINT "ERROR NUMBER IS "; ERR
         PRINT "ERROR AT LINE "; ERL
         PRINT "ERROR MESSAGE IS "; ERT$(ERR)
      END HANDLER
500   END
```

Output

```
ERROR NUMBER IS 50
ERROR AT LINE 20
ERROR MESSAGE IS %Data format error
```

A READ statement is not valid without at least one DATA statement. If your program contains a READ statement but no DATA statement, VAX BASIC signals the compile-time error "READ without DATA".

READ statements can appear either before or after their corresponding DATA statements. The only restriction is that the DATA statements must be in the same order as their corresponding READ statements.

You can have more than one DATA statement in a program. DATA statements are ignored without at least one READ statement. You can use an ampersand to continue a DATA statement. For example:

```
10 DATA "ABRAMS", BAKER, CHRISTENSON, &
        DOBSON, "EISENSTADT", FOLEY
```

Note that comment fields are not allowed in DATA statements. For example, the following statements cause *A$* to contain the string "ABC!COMMENT":

```
READ A$
DATA ABC        !COMMENT
```

When you compile a program, VAX BASIC creates one data block for each program unit. Each data block is local to the program or subprogram containing it; this means that you cannot share DATA statements between program modules.

The data block contains the values in all DATA statements in that program unit. These values are stored in line number order. Each time VAX BASIC executes a READ statement, it retrieves the next value in the data block.

VAX BASIC signals an error if you do one of the following:

- Assign alphabetic characters to a numeric variable. VAX BASIC signals "Data format error" (ERR=50).

- Have more variables in the READ statements than there are values in the DATA statements. VAX BASIC signals "Out of data" (ERR=57).

VAX BASIC ignores excess data in DATA statements.

The following example of READ and DATA mixes string and floating-point data types. The first READ statement reads the first data item in the program: "The diameter is". The second READ statement reads the second data item: 40.5.

Example

```
DATA "The diameter is"
DATA 40.5
READ text$
READ radius
DIAMETER = PI * radius * 2
PRINT text$; DIAMETER
END
```

Output

```
The diameter is 254.469
```

7.1.2.2 The RESTORE Statement

The RESTORE statement lets you read the same data more than once. It has no effect without READ and DATA statements.

RESTORE resets the data pointer to the beginning of the first DATA statement in the program unit. You can then read data values again. Consider the following program.

Example

```
10 READ B,C,D
20 RESTORE
30 READ E,F,G
40 DATA 6,3,4,7,9,2
50 END
```

The READ statement in line 10 reads the first three values in the DATA statement:

B=6
C=3
D=4

The RESTORE statement resets the pointer to the beginning of line 40. During the second READ statement (line 30), the first three values are read again:

E=6
F=3
G=4

Without the RESTORE statement, line 30 would assign the following values:

E=7
F=9
G=2

7.2 Program Output

The PRINT statement displays data on your terminal during program execution. VAX BASIC evaluates expressions before displaying results. Note that you can also print and format data with the PRINT USING statement. For information about the PRINT USING statement, see Chapter 16.

When you use the PRINT statement, VAX BASIC does the following:

- Precedes positive numbers with a space and negative numbers with a minus sign
- Prints a space after every number
- Prints strings without leading or trailing spaces

When an element in a list is not a simple variable or constant, VAX BASIC evaluates the expression before printing the value.

Example

```
A = 45
B = 55
PRINT A + B
END
```

Output

```
 100
```

However, VAX BASIC interprets text inside quotation marks as a string literal.

Example

```
A = 45
B = 55
PRINT "A + B"
END
```

Output

```
A + B
```

The PRINT statement without an expression prints a blank line.

Example

```
PRINT "This example leaves a blank line"
PRINT
PRINT "between two lines."
END
```

Output

```
This example leaves a blank line

between two lines.
```

7.2.1 Print Zones—The Comma and the Semicolon

A terminal line contains zones that are 14 character positions wide. The number of zones in a line depends on the width of your terminal: a 72-character line contains 5 zones, which start in columns 1, 15, 29, 43, and 57. A 132-character line has additional print zones starting at columns 71, 85, 99, and 113.

The PRINT statement formats program output into these zones in different ways, depending on the character that separates the elements to be printed. If a comma precedes the PRINT item, VAX BASIC prints the item at the beginning of the next print zone. If the last print zone on a line is filled, VAX BASIC continues output at the first print zone on the next line.

Example

```
INPUT A ,B ,C ,D ,E ,F
PRINT A ,B ,C ,D ,E ,F
END
```

Output

```
? 5,10,15,20,25,30 [RET]
 5              10              15              20              25
 30
```

VAX BASIC skips one print zone for each extra comma between list elements. For example, the following program prints the value of *A* in the first zone and the value of *B* in the third zone.

Example

```
A = 5
B = 10
PRINT "first zone",,"third zone"
PRINT A,,B
END
```

Output

```
 first zone                     third zone
 5                             10
```

If you separate print elements with a semicolon, VAX BASIC does not move to the next print zone. In the following example, the first PRINT statement prints two numbers. (Printed numbers are preceded by a space or a minus sign and followed by one space.) The second PRINT statement prints two strings.

Example

```
PRINT 10; 20
PRINT "ABC"; "XYZ"
END
```

Output

```
 10  20
ABCXYZ
```

Whether you use a comma or a semicolon at the end of the PRINT statement, the cursor remains at its current position until VAX BASIC encounters another PRINT or INPUT statement. In the following example, VAX BASIC prints the current values of *X*, *Y*, and *Z* on one line because a comma follows the last item in the line PRINT X, Y.

Example

```
INPUT X,Y,Z
PRINT X,Y,
PRINT Z
END
```

Output

```
? 5,10,15
 5             10                   15
```

The following example shows PRINT statements using a comma, a semicolon, and no formatting character after the last print item.

Example

```
!No comma after I%, so each element
!Prints on its own line
!
PRINT I% FOR I% = 1% TO 10%
PRINT
!
!A comma follows J%, so each
!element prints in a separate zone
!
PRINT J%, FOR J% = 1% TO 10%
PRINT
!
!A semicolon follows K%, so print
!elements are packed together
!
PRINT K%; FOR K% = 1% TO 10%
END
```

Output

```
1
2
3
4
5
6
7
8
9
10

1             2              3              4              5
6             7              8              9              10

1  2  3  4  5  6  7  8  9  10
```

Commas and semicolons also let you control the placement of string output.

Example

```
PRINT "first zone",,"third zone",,"fifth zone"
END
```

Output

```
first zone                    third zone                    fifth zone
```

The extra comma between strings causes VAX BASIC to skip another print zone. In the following example, the first string is longer than the print zone. When the two strings are printed, the second string begins in the third print zone because that is the next available print zone after the first string is printed.

Example

```
PRINT "abcdefghijklmnopqrstuvwxyz","foo"
PRINT "first zone","second zone","third zone"
```

Output

```
abcdefghijklmnopqrstuvwxyz  foo
first zone    second zone   third zone
```

7.2.2 Output Format for Numbers and Strings

VAX BASIC prints strings exactly as you type them, with no leading or trailing spaces. It does not print quotation marks unless they are delimited by another matching pair.

Example

```
PRINT 'PRINTING "QUOTATION" MARKS'
END
```

Output

```
PRINTING "QUOTATION" MARKS
```

VAX BASIC follows these rules for printing numbers:

- When you print numeric fields, VAX BASIC precedes each number with a space or a minus sign and follows it with a space.
- VAX BASIC does not print trailing zeros to the right of the decimal point. If all digits to the right of the decimal point are zeros, VAX BASIC omits the decimal point as well.
- When you print LONG integers, VAX BASIC prints up to 10 significant digits.
- When you print DECIMAL values, VAX BASIC prints up to 31 digits.

VAX BASIC follows these rules for printing floating-point numbers:

- If a floating-point number can be represented exactly by six decimal digits (or fewer) and, optionally, a decimal point, VAX BASIC prints it that way.
- When you print a floating-point number whose integer portion is six decimal digits or less (for example, 1234.567), VAX BASIC rounds the number to six digits (1234.57). If the integer portion of the number is seven decimal digits or larger, VAX BASIC rounds the number to six digits and prints it in E format. See the *VAX BASIC Reference Manual* for more information about E format.
- When you print a floating-point number with magnitude between 0.1 and 1, VAX BASIC rounds it to six digits. When you print a floating-point number with more than six digits, and with magnitude smaller than 0.1, VAX BASIC rounds it to six digits and prints it in E format.

The PRINT statement displays only up to six digits of precision for floating-point numbers. This corresponds to the precision of the SINGLE data type. To display the extra digits in DOUBLE, GFLOAT, and HFLOAT numbers, you must use the PRINT USING statement. See Chapter 16 for more information on PRINT USING.

The following example shows how VAX BASIC prints various numbers with single precision.

Example

```
FOR I = 1 TO 20
    PRINT 2^(-I),I,2^I
NEXT I
END
```

Output

```
 .5              1               2
 .25             2               4
 .125            3               8
 .0625           4               16
 .03125          5               32
 .015625         6               64
 .78125E-02      7               128
 .390625E-02     8               256
 .195313E-02     9               512
 .976563E-03     10              1024
 .488281E-03     11              2048
 .244141E-03     12              4096
 .12207E-03      13              8192
 .610352E-04     14              16384
 .305176E-04     15              32768
```

```
.152588E-04    16           65536
.767939E-05    17           131072
.38147E-05     18           262144
.190735E-05    19           524288
.953674E-06    20           .104858E+07
```

7.3 Terminal-Format Files

Terminal-format files let you perform simple I/O to disk files. The records in a terminal-format file must be accessed sequentially. That is, you must access the records in the file one by one, from the first to the last. You can add new records only at the end of the file.

Just as the INPUT, LINPUT, and INPUT LINE statements receive information from a terminal, the INPUT #, LINPUT #, and INPUT LINE # statements receive information from a terminal-format file. And, as the PRINT statement sends information to the terminal, the PRINT # statement sends information to a terminal-format file.

Terminal-format files are very useful for creating files to be printed on a line printer, or for supplying a program with moderate amounts of input. However, if you want to use the same file for both input and output, you should not use terminal-format files. Instead, use sequential, relative, or indexed files. For more information, see Chapter 15.

Note that you do not have to use a program to create a terminal-format file. You can use a text editor to create a file and insert data, then use a VAX BASIC program to open the file and retrieve the data.

7.3.1 Opening and Closing a Terminal-Format File

You use the OPEN statement to create a file, or to gain access to an existing file. If you do not specify either FOR INPUT or FOR OUTPUT in the OPEN statement, VAX BASIC tries to open an existing file. If the file does not exist, VAX BASIC creates a new one.

The channel specification lets you associate a number with the file for as long as the file is open. All I/O operations to or from the file use this number.

When you are finished accessing a file, you close it with the CLOSE statement.

7.3.2 Writing Records to a Terminal-Format File

The following example receives information from a terminal, then writes the information to a terminal-format file as a report.

Example

```
PRINT "This program creates a daily sales report file named SALES.DAT"
OPEN "SALES.DAT" FOR OUTPUT AS FILE #4%
PRINT #4%, "Salesperson","Sales Area","Items Sold"
PRINT #4%
INPUT "How many salespersons for today's report"; sales_persons%
FOR I% = 1% TO sales_persons%
    INPUT "Salesperson's name"; s_name$
    INPUT "Sales area"; area$
    INPUT "Number of items sold"; items_sold%
    PRINT #4%, s_name$, area$, items_sold%
NEXT I%
CLOSE #4%
END
```

Output

```
This program creates a daily sales report file named SALES.DAT
How many salespersons for today's report? 3
Salesperson's name? JONES
Sales area? NJ
Items sold? 5
Salesperson's name? SMITH
Sales area? NH
Items sold? 6
Salesperson's name? BAINES
Sales area? VT
Items sold? 8
```

This program first prints a header explaining its purpose, then opens a terminal-format file on channel 4. After this file is opened, the two PRINT # statements place an explanatory header followed by a blank line into the file.

The program then prompts you for the number of salespersons for which data is to be entered. The FOR...NEXT loop prompts for the name, sales area, and items sold for each salesperson. Note that the FOR...NEXT loop executes only as many times as there are salespersons. See Chapter 11 for more information about FOR...NEXT loops.

After the data has been entered for each salesperson, the program writes this information to the terminal-format file. Because the response to the first question was 3, the FOR...NEXT loop executes three times.

After the last item has been printed to the file, the program closes the file and ends. When you display the file with the DCL command TYPE, you see that the information is printed under the proper headers. You can also print the file on a line printer. Note that the PRINT # statement formats the output in print zones as the PRINT statement does.

Example

```
$TYPE SALES.DAT

Salesman      Sales Area    Items Sold

JONES         NJ             5
SMITH         NH             6
BAINES        VT             8
```

Chapter 8

Arrays

An array is a set of data that is ordered in any number of dimensions. This chapter describes how to create and use VAX BASIC arrays.

8.1 Introduction

A one-dimensional array is called a *list* or *vector*. A two-dimensional array is called a *matrix*. VAX BASIC arrays can have up to 32 dimensions, and a specific type of VAX BASIC arrays can be redimensioned at run time. In addition, you can specify the data type of the values in an array by using data type keywords or suffixes.

The subscript of an element in an array defines that element's position in the array. When you create an array, you specify:

- The number of dimensions that the array contains
- The range of values for the subscripts in each dimension of the array

VAX BASIC arrays are zero-based by default; that is, when calculating the number of elements in a dimension, you count from zero to the number of elements specified. For example, an array with an upper bound of 10 and no specified lower bound, has 11 elements: 0 through 10, inclusive. The array *My_array*(3,3) has 16 elements: 0 through 3 in each dimension, or 4^2.

VAX BASIC also lets you specify a lower bound for any or all dimensions in an array unless the array is a virtual array. By specifying lower and upper bounds for arrays, you can make your array subscripts meaningful. For example, the following array contains sales information for the years 1980 to 1985:

```
DECLARE REAL Sales_data(1980 TO 1985)
```

To refer to an element in the array *Sales_data*, you need only specify the year you are interested in. For example, to print the information for the year 1982, you would type:

```
PRINT Sales_data(1982)
```

You can create arrays either implicitly or explicitly. You implicitly create arrays having any number of dimensions by referencing an element of the array. If you implicitly create an array, VAX BASIC sets the upper bound to 10 and the lower bound to zero. Therefore, any array that you create implicitly contains 11 elements in each dimension.

The following example refers to the array *Student_grades*. If the array has not been previously declared, VAX BASIC will create a one-dimensional array with that name. The array will contain 11 elements.

```
Student_grades(8) = "B"
```

You create arrays explicitly by declaring them in a DIM, DECLARE, COMMON, or MAP statement, or record declaration. Note that if you want to specify lower bounds for your array subscripts, you must declare the array explicitly.

When you declare an array explicitly, the value that you give for the upper bound determines the maximum subscript value in that dimension. If you specify a lower bound, then that is the minimum subscript value in that dimension. If you do not specify a lower bound, VAX BASIC sets the lower bound in that dimension to zero. You can specify bounds as either positive or negative values. However, the lower bound of each dimension must always be less than or equal to the upper bound for that dimension.

You can use MAT statements to create and manipulate arrays. However, MAT statements are valid only on arrays of one or two dimensions. In addition, the lower bounds of all dimensions in an array referenced in a MAT statement must be zero.

8.2 Creating Arrays Explicitly

You can create arrays explicitly with four VAX BASIC statements: DECLARE, DIMENSION, COMMON, and MAP.

In addition, you can declare arrays as components of a record data type. See Chapter 10 for more information on records.

Normally, you use the DECLARE statement to create arrays. However, in certain cases, you may want to create the array with another VAX BASIC statement:

- You use the DIM statement to create virtual arrays and arrays that can be redimensioned at run time.
- You use the COMMON statement to create arrays that can be shared among program modules or to create arrays of fixed-length strings.
- You use the MAP statement to create an array and associate it with a record buffer, or to overlay the storage for an array, thus accessing the same storage in different ways.

When you create an array, the bounds you specify determine the array's size. The maximum value allowed for a bound can be as large as 2147483467; however, this number is actually limited by the amount of virtual storage available to you. Very large arrays and arrays with many dimensions can cause fatal errors at both compile time and run time.

The following restrictions apply to arrays:

- When referencing an array, you must use the same number of subscripts as was specified in the DIM statement.
- You can use identical names for a simple variable and an array; for example, A% and A%(5,5). However, this is not a recommended programming practice. If you use identical names for arrays with a different number of subscripts, for example, A(5), and A(10,10), VAX BASIC prints the error "Inconsistent subscript usage" at compile time.
- If subscript checking is enabled, VAX BASIC signals the error "Subscript out of range" (ERR=55) if you reference an array element whose subscripts are one of the following:
  - Greater than the current upper bound of the array
  - Less than the current lower bound of the array
  - Less than zero where no lower bound was specified

8.2.1 Creating Arrays with the DECLARE Statement

The DECLARE statement creates and names variables and arrays. All elements of arrays created with the DECLARE statement are initialized to zero or the null string. The following statement creates a longword integer array with 11 elements:

```
DECLARE LONG FIRST_ARRAY(1970 TO 1980)
```

Note that the STRING data type with the DECLARE statement causes the creation of an array of dynamic strings. To create an array of fixed-length strings, declare the array in a COMMON or MAP statement or as part of a RECORD structure.

8.2.2 Creating Arrays with the DIM Statement

The DIM statement creates and names one or more arrays. You should use the DIM statement to create an array only when you want to:

- Redimension the array at run time
- Create a virtual array

When creating arrays with DIM, you specify the data type of the array elements with a data type keyword, a special suffix on the array name, or both. The array name can be any valid variable name. If you do not supply a data type keyword, the data type is determined by the suffix of the array name:

- If the array name ends in a dollar sign, the array stores string data.
- If the array name ends in a percent sign, the array stores integer data.
- If the array name does not end in either a percent sign or a dollar sign, the array stores data of the default type. The default type is single-precision, floating-point unless you change the default. See Chapter 6 for more information on default data types.

Even if the DIM statement contains a data type keyword, the array name can still end in the appropriate data type suffix. This makes the data type of the array immediately obvious.

The DIM statement can be either executable or declarative. If the specified bounds are constants, the DIM statement is declarative. This means that the storage is allocated at compile time, and the array cannot appear in any other DIM statement.

However, if any of the specified bounds are variables (simple or subscripted), the DIM statement is executable. This means that the storage for the array is allocated at run time, and the array can be redimensioned with a DIM statement any number of times.

NOTE

> In the DIM statement, bounds can be either constants or variables (simple or subscripted), but not expressions.

When an array is redimensioned with the executable DIM statement, the array can become larger or smaller than it was. However, redimensioning an array in this way causes it to be reinitialized, and all data in the array is lost.

In contrast, MAT statements let you redimension an array to be the same size or smaller than it was. However, MAT statements redimension arrays only when assigning values or performing matrix I/O; therefore, the fact that MAT reinitializes the array does not matter. See Section 8.6 for more information on MAT statements.

8.2.2.1 Declarative DIM Statements

Declarative DIM statements are those with integer constants as bounds. The percent sign is optional for bounds; however, VAX BASIC signals the error "Integer constant required" if a constant bound contains a decimal point. The following statement creates a 101-element virtual array containing string data. The elements of this array can each have a maximum length of 256 characters.

```
DIM #1%, STRING VIRT_ARRAY(100) = 256%
```

The following restrictions apply to the use of declarative DIM statements:

- A declarative DIM statement must lexically precede any reference to the array it dimensions.
- The lower bounds of all virtual array dimensions must be zero.
- You must open a VIRTUAL file on the specified channel before you can access elements of the virtual array.

8.2.2.2 Executable DIM Statements

Executable DIM statements are those with at least one variable bound. Bounds can be constants or simple variables, but at least one bound must be a variable. Executable DIM statements let you redimension an array at run time. The bounds of the array can become larger or smaller, but the number of dimensions cannot change. For example, you cannot redimension a four-dimensional array to be five-dimensional.

The executable DIM statement cannot be used on arrays in COMMON, MAP, DECLARE, or declarative DIM statements, nor on virtual arrays or arrays received as formal parameters.

Whenever an executable DIM statement executes, it reinitializes the array. If you change the values of an executable DIM statement, the initial values are reset each time the DIM statement is executed.

In the following example, the second DIM statement reinitializes the array *real_array*; therefore, *real_array(1%)* equals zero in the second PRINT statement:

Example

```
X% = 10%
Y% = 20%
DIM real_array(X%)
real_array(1%) = 100
PRINT real_array(1%)
DIM real_array(Y%)
PRINT real_array(1%)
END
```

Output

```
100
0
```

You cannot reference an array named in an executable DIM statement until after the DIM statement executes. If you reference an array element declared in an executable DIM statement whose subscripts are larger than the bounds specified in the last execution of the DIM statement, VAX BASIC signals the run-time error "Subscript out of range" (ERR = 55), provided subscript checking is enabled.

8.2.3 Creating Arrays with the COMMON Statement

You should create arrays with the COMMON statement when you need an array of fixed-length strings, or when you want to share an array among program modules. Program modules can share arrays in COMMON statements by defining a common block with the same name.

The COMMON statements in the following programs create a 100-element array of fixed-length strings, each element 10 characters long. Because the main program and subprograms use the same common name, the storage for these arrays is overlaid when the programs are linked. Therefore, both programs can read and write data to the array.

Example

```
!Main Program
COMMON (ABC) STRING access_list(1 TO 100) = 10

!Subprogram
SUB SUB1
COMMON (ABC) STRING new_list(1 TO 100) = 10
```

8.2.4 Creating Arrays with the MAP Statement

You should create arrays with the MAP statement only when you want the array to be part of a record buffer, or when you want to overlay the storage containing the array. Note that string arrays in maps are always fixed-length.

You associate the array with a record buffer by naming the map in the MAP clause of the OPEN statement.

In the following example, the MAP statement creates two arrays: an 11-element fixed-length string array named *team* and a 33-element array of WORD integers named *bowling_scores*. Because the OPEN statement specifies MAP *ABC*, the storage for these arrays is used as the record buffer for the open file.

Example

```
MAP (ABC) STRING team(10) = 20, WORD bowling_scores(0 TO 32)
OPEN "BOWLING.DAT" AS FILE #1%, SEQUENTIAL VARIABLE, MAP ABC
```

8.3 Determining the Bounds of an Array

VAX BASIC provides two built-in functions, LBOUND and UBOUND, that allow you to determine the lower and upper bounds, respectively, for any dimension in an array.

The following example sets up four variables that contain the lower and upper bounds of both dimensions of the array *Sales_data*. These variables represent the years and months for which there is sales data available. The two FOR...NEXT loops print all the sales information in the array, starting with the first year and month, and ending with the last year and month.

Example

```
DECLARE Sales_data(1900 TO 1985, 1 TO 12)

Month_start% = LBOUND (Sales_data, 2)
Year_start% = LBOUND (Sales_data, 1)
Month_end% = UBOUND (Sales_data, 2)
Year_end% = UBOUND (Sales_data, 1)
FOR Year% = Year_start% TO Year_end%

    FOR Month% = Month_start% TO Month_end%
        PRINT Sales_data(Year%, Month%)
    NEXT Month%

NEXT Year%
```

Note that you cannot implicitly declare arrays with the LBOUND and UBOUND functions. These functions can be used only with arrays that have been previously declared.

8.4 Creating Arrays Implicitly

There are two ways to create arrays implicitly:

- By referencing an element of an array that has not been explicitly declared
- By using MAT statements

When VAX BASIC first creates an implicit array, the lower bound is zero and the upper bound is 10. An array created by referencing an element can have up to 32 dimensions in VAX BASIC. An array created with a MAT statement can have only one or two dimensions.

NOTE

The ability to create arrays implicitly exists for compatibility with previous implementations of VAX BASIC. However, it is better

programming practice to declare all arrays explicitly before using them.

If you reference an element of an array that has not been explicitly declared, VAX BASIC creates a new array with the name you specify. Arrays created by reference have default subscripts of (0 TO 10), (0 TO 10, 0 TO 10), (0 TO 10, 0 TO 10, 0 TO 10), and so on, depending on the number of dimensions specified in the array reference. For example, the following program implicitly creates three arrays and assigns a value to one element of each.

Example

```
LET A(5,5,5) = 3.14159
LET B%(3) = 33
LET C$(2,2) = "Russell Scott"
END
```

The first LET statement creates an 11 by 11 by 11 array that stores floating-point numbers and assigns the value 3.14159 to element (5,5,5). The second LET statement creates an 11-element list that stores integers and assigns the value 33 to element (3) and the third LET statement creates an 11 by 11 string array and assigns the value "Russell Scott" to element (2,2).

When you create an implicit numeric array by referring to an element, VAX BASIC initializes all elements (except the one assigned a value) to zero. For implicit string arrays, VAX BASIC initializes all elements (except the one assigned a value) to a null string. When you implicitly create an array, you cannot specify a subscript greater than 10. An attempt to do so causes VAX BASIC to signal "Subscript out of range" (ERR = 55), provided that subscript checking is enabled.

Note that you cannot create an array implicitly, then redimension the array with an executable DIM statement. The DIM statement must execute before any reference to the array.

An array name cannot appear in a declarative statement after the array has been implicitly declared by a reference. The following DECLARE statement is therefore illegal and causes VAX BASIC to signal the compile-time error "illegal multiple definition of name NEW_ARRAY".

```
new_array (5,5,5) = 1
DECLARE LONG new_array (15,10,5)
```

8.5 Assigning and Displaying Array Values

You can assign values to array elements from within your program, from an external source, such as terminal input or from files, or with MAT statements.

You can write data from an array with the following statements:

- LET
- PRINT

The following sections tell you how to perform input and output operations on VAX BASIC arrays.

8.5.1 Assigning Values with the LET Statement

The LET statement assigns values to individual array elements.

Example

```
DIM voucher_num%(100)
    .
    .
    .
LET voucher_num%(20) = 3253%
    .
    .
    .
END
```

You can also assign values to a portion of an array with the LET statement and a FOR...NEXT loop. In the following example, the FOR...NEXT loop assigns zero to array elements (1,5) through (1,10), (2,5) through (2,10), and (3,5) through (3,10).

Example

```
DIM po_number%(100,100)
    .
    .
    .
FOR I% = 1% TO 3%
    FOR J% = 5% TO 10%
           LET po_number%(I%,J%) = 0%
    NEXT J%
NEXT I%
    .
    .
    .
END
```

8.5.2 Listing Array Elements with the PRINT Statement

You print individual array elements by naming those elements in the PRINT statement. For example:

```
PRINT parts_list$(35%)
```

With a FOR...NEXT loop, you can print all or part of an array.

Example

```
DIM capture_ratio(10,10)
    .
    .
    .
FOR Y% = 7% TO 10%
  FOR X% = 7% TO 10%
      PRINT capture_ratio(X%,Y%)
  NEXT X%
NEXT Y%
```

8.6 Using MAT Statements

MAT statements let you assign values to or display entire arrays with a single statement. They also:

- Implicitly create arrays
- Assign names to arrays
- Specify array dimensions
- Redimension existing arrays (to equal or smaller sizes)
- Assign element values
- Print the contents of arrays
- Perform matrix arithmetic

MAT statements are valid only on arrays of one or two dimensions. When MAT statements execute, they use row and column zero to store intermediate calculations. This means that MAT statements can overwrite data stored in row and column zero of your arrays, and you should not depend on data in these elements if your program uses MAT statements.

NOTE

MAT statements cannot be used with arrays that have lower bounds other than zero. An attempt to specify a lower bound

other than zero for an array in a MAT statement results in a compile-time error.

Note that the MAT statements discussed in this section are not related to the MAT GRAPH and MAT PLOT graphics statements. For more information on these statements, see *Programming with VAX BASIC Graphics*.

The default subscripts for arrays created implicitly with MAT statements are (10) or (10,10). The default is two dimensions. This means that if you create an array with a MAT statement and do not specify any subscripts, VAX BASIC creates a two-dimensional, 11 by 11 array. If you specify a single subscript, VAX BASIC creates a one-dimensional array with 11 elements.

Table 8–1 lists MAT statements and explains their functions.

Table 8–1: MAT Statements

Statement	Function
MAT	Assigns values of zero, 1, or a null string to array elements. Also copies the values of one array to another and performs matrix arithmetic.
MAT INPUT [#]	Assigns values to array elements from your terminal or a terminal-format file.
MAT LINPUT [#]	Assigns string values to string array elements from your terminal or from a terminal-format file.
MAT PRINT [#]	Displays the contents of an array on your terminal, or writes array element values to a terminal-format file.
MAT READ	Assigns DATA statement values to array elements.

In the following example, the first MAT statement creates the string array *z_array$* with eight rows and eight columns and assigns a null string to all elements. The second MAT statement redimensions the array to six rows and six columns. The third MAT statement adds the values in each corresponding element of arrays *B* and *C* and stores the values in the corresponding elements of array *A*.

Example

```
MAT z_array$ = NUL$(7,7)
MAT z_array$ = NUL$(5,5)
MAT A = B + C
END
```

8.6.1 The MAT Statement

The MAT statement can create an array and optionally assign values to all elements in that array. By specifying one of the MAT statement keywords, you can initialize arrays in one of four ways. Table 8–2 lists the MAT statement keywords and their functions.

Table 8–2: MAT Statement Keywords

MAT Keyword	Function
ZER	Sets the value of all elements in a numeric array to zero.
CON	Sets the value of all elements in a numeric array to 1, except those in row and column zero.
IDN	Sets the array to the identity matrix, that is, it sets the value of all elements in real or integer arrays to zero, except for those elements on the diagonal from element (1,1) to element (n,n), where n is the largest subscript in the array. The elements on the diagonal are set to 1. IDN applies to square arrays only.
NUL$	Sets the value of all elements in a string array to the null string, except those in row and column zero.

The array name can specify an existing array. MAT statements do not assign values to row and column zero.

Note that the MAT statement does not require subscripts. In the case of existing arrays:

- If you do not specify subscripts, VAX BASIC does not change the current subscripts.
- If you specify subscripts, VAX BASIC redimensions the array to the specified subscripts. When redimensioning arrays with MAT, you cannot increase the total number of array elements (including those in row and column zero).

When you are creating arrays with MAT:

- If you do not supply subscripts, VAX BASIC assigns two subscripts, each with a value of 10.
- If you specify subscripts, they define the dimensions of the array being implicitly created. Subscript values cannot exceed 10.

Example

```
DIM A(10,10), B(15), C(20,20)
MAT A = ZER              !Sets all elements of A to 0
MAT B = CON(10)          !Sets elements of B to 1; redimensions B
MAT C = IDN(10,10)       !Redimensions C to 10x10 identity matrix
PRINT "ARRAY A:"
MAT PRINT A;
PRINT
PRINT "ARRAY B:"
MAT PRINT B;
PRINT
PRINT "ARRAY C:"
MAT PRINT C;
```

Output

```
ARRAY A:
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0

ARRAY B:
1  1  1  1  1  1  1  1  1  1

ARRAY C:
1  0  0  0  0  0  0  0  0  0
0  1  0  0  0  0  0  0  0  0
0  0  1  0  0  0  0  0  0  0
0  0  0  1  0  0  0  0  0  0
0  0  0  0  1  0  0  0  0  0
0  0  0  0  0  1  0  0  0  0
0  0  0  0  0  0  1  0  0  0
0  0  0  0  0  0  0  1  0  0
0  0  0  0  0  0  0  0  1  0
0  0  0  0  0  0  0  0  0  1
```

8.6.2 The MAT READ Statement

The MAT READ statement assigns values from DATA statements to array elements. Subscripts define either the dimensions of the array being created or the new dimensions of an existing array; subscripts are optional in MAT READ statements.

If you do not provide enough data in DATA statements to fill the specified array, VAX BASIC leaves the remaining array elements unchanged. If you provide more data values than there are array elements, VAX BASIC assigns enough values to fill the array and leaves the DATA pointer at the next value.

In the following example, VAX BASIC fills matrix *B* with the first four DATA items, fills matrix *C* with the next four DATA values, and leaves the DATA pointer at the ninth value in the DATA list.

Example

```
MAT READ B(2,2)
MAT READ C(2,2)
PRINT
PRINT "MATRIX B"
PRINT
PRINT
MAT PRINT B;
PRINT
PRINT "MATRIX C"
PRINT
PRINT
MAT PRINT C;
DATA 1,2,3,4,5,6,7,8,9,10
END
```

Output

```
MATRIX B

 1  2
 3  4
MATRIX C

 5  6
 7  8
```

8.6.3 The MAT INPUT [#] Statement

The MAT INPUT statement assigns values from your terminal to array elements. The MAT INPUT # statement reads data from a terminal-format file and writes it to an array. The optional subscripts in a MAT INPUT statement define either the dimensions of the array being created implicitly or the new dimensions of an existing array. If you are implicitly creating the array, the value of a subscript cannot exceed 10.

The MAT INPUT statement requests data from your terminal, as does the INPUT statement; it prints a question mark (?) prompt that you can disable with the SET NO PROMPT statement and then enable with the

SET PROMPT statement. However, you cannot include a string prompt with the MAT INPUT statement.

When you enter a series of values separated by commas, VAX BASIC enters the values you supply into successive array elements by row, starting with element (1,1) and filling row 1 before starting row 2. If you provide fewer data items than there are elements, the remaining elements are unchanged. If you provide more items than there are elements, VAX BASIC ignores the excess.

The MAT INPUT # statement takes values from an open file and assigns them to the matrix elements by rows, starting with element (1,1). It fills the elements in row 1 before starting row 2. The file can have one or more values in each record; however, multiple values must be separated with commas.

In the following example, the open file on channel 3 contains the following data: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13. The MAT INPUT # statement reads this data and uses it to fill the array *A*, filling in row 1 before beginning row 2. The MAT INPUT B(2,2) statement dimensions array *B* to 9 elements (0 to 2 in each dimension) and provides values for all the elements except those in row and column zero.

Example

```
MAT INPUT #3, A
PRINT
MAT PRINT A;
MAT INPUT B(2,2)
PRINT
MAT PRINT B;
```

Output

```
 1  2  3  4  5  6  7  8  9  10
11 12 13  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0

? 1,2,3,4

 1  2
 3  4
```

Note that the MAT PRINT statement does not print row and column zero. For more information on the MAT PRINT statement, see Section 8.6.5.

The MAT INPUT statement can also redimension an existing array.

Example

```
DIM new_array%(5,5)
MAT INPUT new_array%(2,4)
MAT PRINT new_array%;
END
```

Output

```
 ? 1,2,3,4,5,6,7,8

 1 2 3 4
 5 6 7 8
```

When entering values in response to MAT INPUT, you can enter an ampersand as the last character on the line and continue on the next line.

8.6.4 The MAT LINPUT [#] Statement

The MAT LINPUT statement assigns string values to string array elements. The MAT LINPUT # statement reads string values from a terminal-format file and writes them to a string array.

The MAT LINPUT statement prompts for individual array elements. It fills the array by rows, starting with element (1,1). It assigns the line you supply (including commas, semicolons, and quotation marks, but excluding the line terminator) to an array element.

Example

```
DIM emp_nam$(5,5)
MAT LINPUT emp_nam$(2,2)
PRINT emp_nam$(1,1)
PRINT emp_nam$(1,2)
PRINT emp_nam$(2,1)
PRINT emp_nam$(2,2)
END
```

Output

```
? HODGES
? LAFFERTY
? ELDON
? HOPKINS
HODGES
LAFFERTY
ELDON
HOPKINS
```

By specifying the subscripts (2,2), MAT LINPUT redimensions the array to four elements and overwrites the old values. VAX BASIC then prompts for these elements.

MAT LINPUT # also excludes line terminators when assigning values to string array elements. MAT LINPUT # places the values from the open file into the specified array, filling the array by rows, starting with element (1,1). If there are more values in the file than there are array elements, VAX BASIC ignores the excess. If there are fewer, VAX BASIC assigns a null string to the remaining elements.

The following program reads 50 records from the open disk file and assigns them to the array named *part_name$*. If there are more than 50 records in the file, VAX BASIC ignores the excess. If there are fewer than 50 records, then VAX BASIC fills the remaining elements of the array with the null string.

Example

```
DIM part_name$(50)
MAT LINPUT #1%, part_name$
```

8.6.5 The MAT PRINT [#] Statement

The MAT PRINT statement prints some or all of an array's elements, excluding row and column zero. The MAT PRINT # statement takes values from an array by row, starting with element (1,1), and writes each element to a sequential record in the terminal-format file.

Subscripts are optional in MAT PRINT statements. If you do not specify subscripts, MAT PRINT displays the entire array, excluding row and column zero. If you specify subscripts, MAT PRINT displays the specified subset of the array. In the case of the MAT PRINT # statement, the subscripts determine how many array elements are written to the file. The MAT PRINT [#] statement does not redimension an existing array.

If the last character in the MAT PRINT [#] array list is a semicolon, VAX BASIC begins each array row on a separate line. Data values on each line are packed together with no intermediate spaces. However, if the last character in the MAT PRINT [#] array list is a comma, VAX BASIC begins each array row on a separate line and each data value in a separate print zone.

If there is neither a comma nor a semicolon after the array name, VAX BASIC prints each array element on a separate line. In the following example, the first MAT PRINT statement does not end in a comma or semicolon, so each element is printed on a separate line. The second MAT PRINT statement prints the elements twice, the first time starting each element in a new print zone, and the second time leaving a space before and after each value. The MAT PRINT # statement sends the last two lines of output to a terminal-format file.

Example

```
MAT INPUT A(5)
PRINT
MAT PRINT A
PRINT
MAT PRINT A, A;
MAT PRINT #3, A, A;
END
```

Output

```
? 5

  5
  0
  0
  0
  0

  5         0           0           0           0

  5  0  0  0  0
```

8.6.6 Matrix I/O Functions (NUM and NUM2)

MAT statements do not signal error messages when there are more data items than array elements to contain them or when there are fewer data items than array elements to contain them.

VAX BASIC provides two functions that let you determine how much data the MAT statements transfer: NUM and NUM2.

For two-dimensional arrays, the NUM function returns an integer value specifying the row number of the last data item transferred, whereas the NUM2 function returns an integer value specifying the column number of the last data item transferred. For one-dimensional arrays, the NUM function returns the number of items entered, whereas the NUM2 function returns a zero.

With these functions, you can determine the number of items transferred from a terminal-format file. Note, however, that you cannot use the NUM and NUM2 functions to implicitly declare an array. In the following example, the terminal-format file EMP.DAT contains the values 1 through 17, inclusive. When these values are read using the MAT INPUT # statement, NUM and NUM2 represent the row and column number, respectively, of the last value read.

Example

```
OPEN "EMP.DAT" FOR INPUT AS FILE #3%
DIM emp_name$(5,5)
MAT INPUT #3%, emp_name$
PRINT NUM, NUM2
END
```

Output

```
 4              2
```

8.7 Matrix Operators

VAX BASIC provides a special set of MAT statements for array computations. These statements enable you to add, subtract, and multiply matrices, and to assign values to elements. Note that if you specify an array without subscripts (for example, MAT A), the default is two dimensions.

VAX BASIC also provides matrix functions to transpose and invert matrices, and to find the determinant of a matrix you invert.

NOTE

MAT operators do not operate on elements in row or column zero.

8.7.1 Arithmetic Matrix Operations

MAT operators perform matrix assignment, addition, subtraction, and multiplication.

All of these operations use the keyword MAT, followed by an expression. If the array has not been previously dimensioned, these operations create an array. The created output array's dimensions depend on the operation performed, but must be (10,10) or smaller.

NOTE

You can use the MAT operators on arrays larger than (10,10) if the input and output arrays are explicitly created or received as a formal parameter.

8.7.1.1 Assignment

You can assign all values in one array to another array with the MAT statement. In the following example, each element of *new_array* is set to the corresponding element in *old_array*. The dimensions of *new_array* are also redimensioned to the dimensions of *old_array*.

```
MAT new_array = old_array
```

8.7.1.2 Addition and Subtraction

You can add the elements of two arrays. In the following statement, the two input lists, *first_list%* and *second_list%*, must have identical dimensions. The elements of the new list, *sum_list%*, equal the sum of the corresponding elements in the input lists.

```
MAT sum_list% = first_list% + second_list%
```

You can also subtract the elements of two arrays. The following program subtracts one array from another:

Example

```
DIM first_array(30,30)
DIM second_array(30,30)
DIM difference_array(30,30)
    .
    .
    .
MAT difference_array = first_array - second_array
```

Each element of *difference_array* is the arithmetic difference of the corresponding elements of the input arrays.

8.7.1.3 Multiplication

You can multiply the elements of two arrays, provided that the number of columns in the first array equals the number of rows in the second array. The resulting array contains the dot product of the two input arrays.

Example

```
DIM A(2,2), B(2,2), C(2,2)
A(1,1) = 1
A(1,2) = 2
A(2,1) = 3
A(2,2) = 4
B(1,1) = 5
B(1,2) = 6
B(2,1) = 7
B(2,2) = 8
MAT C = A * B
MAT PRINT C
```

Output

```
 19
 22
 43
 50
```

You can also multiply a matrix by a scalar quantity. VAX BASIC multiplies each element of the input array by the scalar quantity you supply. The output array has the same dimensions as the input array. Enclose the scalar quantity in parentheses. The following example multiplies the elements of *inch_array* by the inch-to-centimeter conversion factor and places these values in *cm_array*.

Example

```
DIM inch_array(5), cm_array(5)
MAT READ inch_array
DATA 1,12,36,100,39.37
MAT cm_array = (2.54) * inch_array
MAT PRINT cm_array,
END
```

Output

```
 2.54      30.48      91.44      254      99.9998
```

8.7.2 Matrix Functions

VAX BASIC provides three matrix functions:

- TRN
- INV
- DET

With these functions, you can transpose and invert matrices, and find the determinant of an inverted matrix.

8.7.2.1 The TRN Function

The TRN function transposes a matrix. When you transpose a matrix, VAX BASIC interchanges the array's dimensions. For example, a matrix with n rows and m columns is transposed to a matrix with m rows and n columns. The elements in the first row of the input matrix become the elements in the first column of the output matrix. You cannot transpose a matrix to itself; MAT A = TRN(A) is invalid.

This example creates a 3 by 5 matrix, transposes it, and prints the results.

Example

```
DIM B(3,5)
MAT READ B
MAT A = TRN(B)
DATA 1,2,3,4,5
DATA 6,7,8,9,10
DATA 11,12,13,14,15
MAT PRINT B;
MAT PRINT A;
END
```

Output

```
 1 2 3 4 5
 6 7 8 9 10
 11 12 13 14 15

 1  6   11
 2  7   12
 3  8   13
 4  9   14
 5  10  15
```

8.7.2.2 The INV Function

The INV function inverts a matrix. VAX BASIC can invert a matrix only if its subscripts are identical and it can be reduced to the identity matrix by elementary row operations. The input matrix multiplied by the output matrix (its inverse) always gives the identity matrix as a result.

Example

```
MAT INPUT first_array(3,3)
MAT PRINT first_array;
PRINT
MAT inv_array = INV (first_array)
MAT PRINT inv_array;
PRINT
MAT mult_array = first_array * inv_array
MAT PRINT mult_array;
```

Output

```
? 4,0,0,0,0,2,0,8,0
 4  0  0
 0  0  2
 0  8  0

 .25  0  0
 0  0  .125
 0  .5  0

 1  0  0
 0  1  0
 0  0  1
```

8.7.2.3 The DET Function

The DET function returns the determinant of a matrix. The DET function returns a floating-point number that is the determinant of the last matrix inverted. If you use the DET function before inverting a matrix, the value of DET is zero.

Chapter 9

Data Definition

This chapter describes how to define program objects, explicitly assign data types to program variables, and allocate and use data storage.

9.1 Declarative Statements

You use declarative statements to define objects in a VAX BASIC program. Objects can be variables, arrays, constants, and user-defined functions within a program module. They can also be routines, variables, and constants external to the program module. Declarative statements always assign names to the objects declared and usually assign other attributes, such as a data type, to them. Declarative statements can also be used to define user-defined data types (RECORD statements). See Chapter 10 in this manual for more information on the RECORD statement.

You use declarative statements to assign data types to:

- Variables
- Arrays
- Named constants
- Values returned by functions

By declaring the objects used in your program, you make the program much easier to understand, modify, and debug.

9.2 Data Types

At its most fundamental level, a data type is a format for information storage. All information is stored in the computer as bit patterns (groups of ones and zeros). Data types specify how the computer should interpret these patterns.

VAX BASIC programs allow four general data types: integer, floating-point, string, and packed decimal. Each data type is suited for a particular type of task. For example, integers are useful for numeric computations involving whole numbers, strings provide a way to manipulate alphanumeric characters, and packed decimal data is useful for manipulating numeric values that require precise representation.

Within integer and floating-point data types there are further subdivisions. For example, integers can be classed as BYTE, WORD, and LONG. Choosing one of these integer subdivisions lets you control two things:

- The amount of storage required for the integer
- The range of values that the integer can accept

See Table 9–1 for more information on the range and storage requirements of these integer subtypes.

Similarly, floating-point data can be classed as SINGLE, DOUBLE, GFLOAT, and HFLOAT. See Table 9–1 for more information on the range and storage requirements of these floating-point subtypes.

In addition to numeric and string data types, VAX BASIC also provides a unique data type called RFA. Variables of the RFA data type require six bytes of storage and can contain only a Record File Address. RFA variables are used with RMS file I/O; the operations that can be performed on them are strictly limited. See the *VAX BASIC Reference Manual* for more information on the RFA data type. Finally, VAX BASIC allows you to construct your own forms of data representation using records.

Traditionally, VAX BASIC programs have had just three data types: integer, string, and floating-point. A data type was assigned to a variable with a suffix on the variable names; a dollar sign ($) denoted a string variable, a percent sign (%) denoted an integer variable, and variable names without suffixes denoted floating-point variables. By referencing a variable in your program, you would implicitly declare the variable with the data type indicated by the suffix character.

VAX BASIC now lets you explicitly assign data types to variables, parameters, and functions. This feature gives you more control over the storage and precision used by your program. You can, however, still use implicit data typing in your programs. You can ensure that all program variables are explicitly declared by specifying OPTION TYPE = EXPLICIT or by using the /TYPE=EXPLICIT qualifier when you compile your programs. See Section 9.3 for more information on the OPTION statement.

Table 9–1 lists the keywords you use to assign data types along with their size, range, and precision.

Table 9–1: VAX BASIC Data Types

Data Type Keyword	Size	Range	Precision (decimal) (digits)
INTEGER			
BYTE	8 bits	–128 to +127	NA
WORD	16 bits	–32768 to +32767	NA
LONG	32 bits	–2147483648 to +2147483647	NA
REAL			
SINGLE	32 bits	$.29 * 10^{-38}$ to $1.7 * 10^{38}$	6
DOUBLE	64 bits	$.29 * 10^{-38}$ to $1.7 * 10^{38}$	16
GFLOAT	64 bits	$.56 * 10^{-308}$ to $.90 * 10^{308}$	15
HFLOAT	128 bits	$.84 * 10^{-4932}$ to $.59 * 10^{4932}$	33
DECIMAL			
DECIMAL(d,s)	0 to 16 bytes	$1 * 10^{-31}$ to $1 * 10^{31}$	NA

(continued on next page)

Table 9–1 (Cont.): VAX BASIC Data Types

Data Type Keyword	Size	Range	Precision (decimal) (digits)
STRING			
STRING	One character per byte	Max = 65535	NA
RFA			
RFA	6 bytes	NA	NA

As shown in Table 9–1, there are four data type keywords that specify integer data. The data type INTEGER is a general data type because it specifies only that a variable contains integer data. The subtypes BYTE, WORD, and LONG specify exactly how much storage is allocated to an integer variable. If you specify the INTEGER data type, the subtype of integer variables depends on the default integer data type in effect when the program is compiled. This default is determined by one of two things:

- The program's OPTION statement, if present. See Section 9.3 for more information on the OPTION statement.
- The /INTEGER_SIZE qualifier you use to compile the program.

Similarly, there are five data type keywords that specify floating-point data. The data type REAL is a general data type because it specifies only that a variable contains floating-point data. The subtypes SINGLE, DOUBLE, GFLOAT, and HFLOAT specify exactly how much storage is allocated to a floating-point variable. If you specify the data type REAL, the subtype of floating-point variables depends on the default floating-point subtype in effect when the program is compiled. This default is determined by one of two things:

- The OPTION statement, if present
- The /REAL_SIZE qualifier you use to compile the program

Choosing a numeric subtype always involves a tradeoff between storage requirements and range or precision. You can reduce the size of an executable image by choosing the smallest numeric subtype that is large enough to meet your needs.

9.3 Setting the Default Data Type and Size

There are two ways to set the default data type and size for your program:

- With the OPTION statement
- With qualifiers:
  - /TYPE_DEFAULT
  - /INTEGER_SIZE
  - /REAL_SIZE
  - /DECIMAL_SIZE

The OPTION statement can override the defaults set with qualifiers. For example, the following statement sets the default integer type to be LONG:

```
OPTION SIZE = INTEGER LONG
```

You can have more than one OPTION statement in a program module; however, OPTION statements can be preceded only by a SUB, FUNCTION, REM, or another OPTION statement.

Note that the OPTION statement can also specify the following:

- Integer and packed decimal overflow checking
- Program optimization
- Rounding or truncation of packed decimal numbers
- Subscript checking

See the *VAX BASIC Reference Manual* for more information about the OPTION statement.

The OPTION statement in the following example specifies that all program variables must be explicitly typed and that all implicitly typed constants are INTEGER. In addition, any variable typed as INTEGER is a LONG integer and any variable typed as REAL is a DOUBLE floating-point number.

```
OPTION  TYPE = EXPLICIT,          ! Variables must be declared        &
        CONSTANT TYPE = INTEGER,  ! All implicit constants be integers &
        SIZE = INTEGER LONG,      ! 32-bit integers by default        &
        SIZE = REAL DOUBLE        ! 64-bit floating-point
                                  ! numbers by default
```

You can create variables of other data types by explicitly declaring them with the DECLARE, COMMON, or MAP statement.

9.4 Declaring Variables Explicitly

The DECLARE statement explicitly assigns a data type or subtype to a variable, function, or constant.

The subtype you specify overrides any defaults specified in the OPTION statement, in the BASIC environment or with the /INTEGER_SIZE, /REAL_SIZE, and /DECIMAL_SIZE qualifiers. For example, if you compile your program with the /INTEGER_SIZE=WORD qualifier and declare an integer variable to be LONG, the variable is LONG rather than WORD. In this format of the DECLARE statement, the data type STRING specifies a dynamic string variable.

You can define a variable only once in a program. For example, if a variable name appears in a DECLARE statement, it cannot also appear in a COMMON or MAP statement.

You should use unique variable names to avoid confusion and make program documentation easier. For example, if you declare variable *B* to be LONG, there cannot also be a floating-point variable *B* in your program. It is possible to have both an INTEGER variable *B%* and an INTEGER variable *B* in the same program; however, this is poor programming practice.

When you explicitly declare an array, VAX BASIC allows you to specify both upper and lower bound values. The value you supply as the upper bound determines the maximum subscript value for a given dimension, and the value you supply for the lower bound determines the minimum subscript value for a given dimension.

For more information on specifying bounds with the DECLARE statement, see the *VAX BASIC Reference Manual* and Chapter 8 in this manual.

You can also use the DECLARE statement to assign a data type and value to DEF functions and constants. See Section 9.5 for an explanation of declaring named constants.

The following statement declares the DEF function *circumference* and declares a SINGLE parameter for the function:

```
DECLARE LONG FUNCTION circumference(SINGLE)
```

DECLARE FUNCTION lets you assign a data type to parameters and to the value a function returns. DECLARE FUNCTION also lets you name the function without using the usual convention (beginning the function name with FN and ending the function name with a percent or dollar sign suffix).

Example

```
DECLARE STRING FUNCTION concat (STRING, STRING) !Declare the function
    .
    .
    .
new_string$ = concat(A$, B$)                    !Invoke the function
DEF concat (STRING Y, STRING Z)                 !Define the function
concat = Y + Z
END DEF
    .
    .
    .
END
```

This format allows only one data type in a single statement. Declaring more than one type of function requires a DECLARE statement for each type.

These data typing features give you control over storage allocation. Compiling a program with OPTION TYPE = EXPLICIT is particularly useful because it causes VAX BASIC to signal an error when an implicit variable is encountered. This prevents a typing mistake from being interpreted as a new variable. DIGITAL supports implicit variables for compatibility with other versions of BASIC and also because they are useful for beginning programmers. However, DIGITAL recommends that you use explicit declarations for new program development.

9.5 Declaring Named Constants Explicitly

Constants are values that do not change during program execution. You can declare named constants within a program unit with the DECLARE statement. You can also refer to constants outside the program unit with the EXTERNAL statement. In addition, VAX BASIC provides notation for binary, octal, decimal, and hexadecimal constants.

Named constants are useful for the following reasons:

- If a commonly-used constant must be changed, you can make the change in a single place.
- They make the program easier to understand.

9.5.1 Declaring Constants Within a Program Unit

The value assigned to a named constant need not be in the allowable range of the default data type; however, it must be in the valid range of the data type being declared. The following statement declares a LONG constant named *XYZ* and assigns it a value of 1000. In DECLARE CONSTANT statements, VAX BASIC signals an overflow error only if the value is outside the range of the data type being declared.

```
DECLARE LONG CONSTANT XYZ = 1000
```

The following example declares a double-precision constant.

Example

```
DECLARE DOUBLE CONSTANT plancks = 6.6237E-27
INPUT "FREQUENCY"; freq
PRINT "ENERGY EQUALS"; plancks / freq
END
```

A DECLARE CONSTANT statement allows only one data type. To declare constants of different data types, you must use additional DECLARE CONSTANT statements.

9.5.2 Declaring Constants External to the Program Unit

To declare constants external to the program unit, use the EXTERNAL statement. For example:

```
EXTERNAL LONG CONSTANT SS$_NORMAL
```

The VMS Linker automatically supplies the values for constants specified in EXTERNAL statements. For more information on using the EXTERNAL statement, see the *VAX BASIC Reference Manual*.

9.5.3 Declaring a Default Constant Type

To declare a default constant type, specify a CONSTANT TYPE clause with the OPTION statement. This CONSTANT TYPE clause specifies the data type for all constants that do not end in a data type suffix or are not in explicit literal notation with a data type supplied. For instance, the following OPTION statement specifies that all implicitly typed constants will be INTEGER:

```
OPTION CONSTANT TYPE = INTEGER
```

9.6 Operations with Multiple Data Types

When an expression contains operands of different data types, it is called a *mixed-mode* expression. Before a mixed-mode expression can be evaluated, the operands must be converted, or *promoted*, to a common data type. The result of the evaluation may also be converted depending on the data type of the variable to which it is assigned.

When evaluating mixed-mode expressions, VAX BASIC performs promotions such that no operand loses any range or precision. When assigning values to variables, VAX BASIC converts the result of the expression to the data type of the variable. If the value of the expression is outside the allowable range of the variable's data type, VAX BASIC signals "Integer error or overflow", "Floating-point error or overflow", or "DECIMAL error or overflow".

In general, VAX BASIC promotes operands with different data types to the lowest data type that can hold the largest and most precise possible value of either operand's data type. VAX BASIC then performs the operation in that data type, and yields a result of that data type. If the result of the expression is assigned to a variable, VAX BASIC converts the result to the data type of the variable. Table 9–2 lists the resulting data type for all combinations except those involving DECIMAL data types.

Table 9–2: Result Data Types in VAX BASIC Expressions

	BYTE	**WORD**	**LONG**	**SINGLE**	**DOUBLE**	**GFLOAT**	**HFLOAT**
BYTE	BYTE	WORD	LONG	SINGLE	DOUBLE	GFLOAT	HFLOAT
WORD	WORD	WORD	LONG	SINGLE	DOUBLE	GFLOAT	HFLOAT
LONG	LONG	LONG	LONG	SINGLE	DOUBLE	GFLOAT	HFLOAT
SINGLE	SINGLE	SINGLE	SINGLE	SINGLE	DOUBLE	GFLOAT	HFLOAT
DOUBLE	DOUBLE	DOUBLE	DOUBLE	DOUBLE	DOUBLE	HFLOAT	HFLOAT
GFLOAT	GFLOAT	GFLOAT	GFLOAT	GFLOAT	HFLOAT	GFLOAT	HFLOAT
HFLOAT	HFLOAT	HFLOAT	HFLOAT	HFLOAT	HFLOAT	HFLOAT	HFLOAT

For example, if one operand is SINGLE and one operand is DOUBLE, VAX BASIC promotes the SINGLE value to DOUBLE, performs the specified operation, and returns the result as a DOUBLE value. This promotion is necessary because the SINGLE data type has less precision than the DOUBLE value, whereas the DOUBLE data type can hold the largest and most precise possible SINGLE value. If VAX BASIC did not promote the SINGLE value and the operation yielded a more precise result than was represented in SINGLE, the value would lose precision.

With one exception, the resulting data type is the same as that of the operand with the higher data type. The exception is when the operands are DOUBLE and GFLOAT. When an expression contains a DOUBLE and a GFLOAT operand, VAX BASIC promotes both values to HFLOAT, and returns an HFLOAT value. This is necessary because a DOUBLE value is more precise than a GFLOAT value, but cannot contain the largest possible GFLOAT value. Consequently, VAX BASIC promotes these data types to a data type that can hold the largest and most precise value of either operand.

VAX BASIC also allows the DECIMAL(d,s) data type. DECIMAL values are converted to REAL before exponentiation. For all other operations involving a DECIMAL value, the number of digits (d) and the scale or position of the decimal point (s) in the result depend on the data type of the other operand. If one operand is DECIMAL and the other is DECIMAL or INTEGER, the d and s values of the result are determined as follows:

- If both operands are typed DECIMAL, and if both operands have the same digit (d) and scale (s) values, no conversions occur and the result of the operation has exactly the same d and s values as the operands. Note, however, that overflow can occur if the result exceeds the range specified by the d value.
- If both operands are DECIMAL, but have different digit and scale values, VAX BASIC always uses the larger number of specified digits for the result.

In the following statements, variable *A* allows three digits to the left of the decimal point and two digits to the right. Variable *B* allows one digit to the left of the decimal point and three digits to the right.

```
DECLARE DECIMAL(5,2) A
DECLARE DECIMAL(4,3) B
```

Therefore, the result allows three digits to the left of the decimal point and three digits to the right.

If one operand is typed DECIMAL and one is typed INTEGER, the INTEGER value is converted to a DECIMAL(d,s) data type as follows:

- BYTE is converted to DECIMAL(3,0).
- WORD is converted to DECIMAL(5,0).
- LONG is converted to DECIMAL(10,0).

VAX BASIC then determines the d and s values of the result by evaluating the d and s values of the operands previously described. Note that only INTEGER data types are converted to the DECIMAL data type. If one operand is DECIMAL and one is floating-point, the DECIMAL value is converted to a floating-point value. The total number of digits (d) in the DECIMAL value determines its new data type:

Range of d	Converted to:
<=1 through <= 6	SINGLE
<= 7 through <= 15	DOUBLE
	GFLOAT
	HFLOAT
= 16	DOUBLE
<= 17 through <= 31	HFLOAT

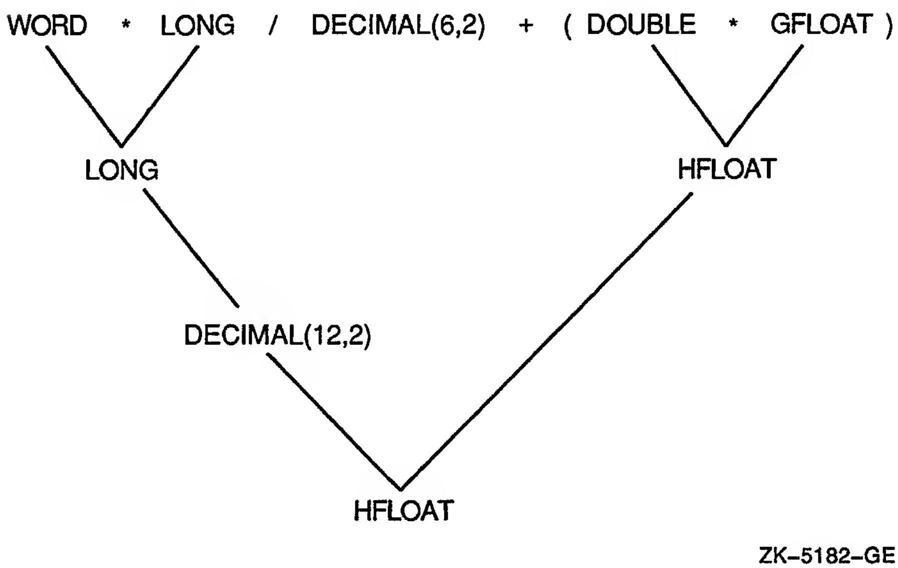
If the value of d is between 7 and 15, the operand is converted to DOUBLE if the floating-point operand is DOUBLE, to GFLOAT if the floating-point operand is GFLOAT, and to HFLOAT if the floating-point operand is HFLOAT. Thus, a DECIMAL(8,5) operand is converted to DOUBLE if the other operand is SINGLE or DOUBLE, to GFLOAT if the other operand is GFLOAT, and to HFLOAT if the other operand is HFLOAT.

Figure 9–1 shows a mixed-mode expression, and the data types of the intermediate and final results.

Note that the LONG integer is first converted to DECIMAL(10,0). When VAX BASIC performs the division, both operands are converted to DECIMAL(12,2).

You can convert any numeric variable or expression to a specified data type with the REAL, INTEGER, and DECIMAL functions. See the *VAX BASIC Reference Manual* for more information on these functions.

Figure 9–1: Mixed-Mode Expression Results



9.7 Allocating Static Storage

VAX BASIC programs allocate both static and dynamic storage. The size of static storage does not change during program execution. Variables and arrays appearing in MAP or COMMON statements use static storage. Because this storage is static, all string variables appearing in MAP or COMMON statements are fixed-length strings.

Dynamic storage is allocated when the program executes. Variables and arrays declared in the following statements use dynamic storage:

- DECLARE statements
- DIMENSION statements
- Implicitly declared variables

Normally, string variables and arrays declared in this way are dynamic strings, and their length can change during program execution. However, if you declare or dimension an array of a user-defined data type (a RECORD name), then all string variables and arrays are fixed-length strings. See Chapter 10 in this manual for more information about the RECORD statement.

MAP and COMMON statements create a named storage area called a program section, or PSECT. MAP statements require a map name, but in COMMON statements the name is optional. The PSECT name is the same as the map or common name. If you do not specify a common name, VAX BASIC supplies a default PSECT name of $BLANK. The following sections explain how to use static storage.

9.7.1 The COMMON Statement

The COMMON statement defines a named area of storage (called a PSECT). Any VAX BASIC subprogram can access the values in a common by specifying a common with the same name. An item in a COMMON statement can be any one of the following:

- A numeric variable
- A numeric array
- A fixed-length string variable
- An array of fixed-length strings
- A RECORD instance
- A FILL item

The amount of storage reserved for a variable depends on its data type. You can specify a length for string variables and string array elements that appear in a COMMON statement. If you do not specify a length, the default is 16. The following statement specifies 2 bytes for *emp.code*, 3 bytes for *wage.code*, and 22 bytes for *dep.code*:

```
COMMON (code) STRING emp.code=2, wage.code=3, dep.code=22
```

In a single program module, multiple common areas with the same name allocate storage end-to-end in a single PSECT. That is, VAX BASIC concatenates all common areas with the same name in the same program module, in the order they appear. For example, the following statements allocate storage for five LONG integers in a single PSECT named *into*:

```
COMMON (into) LONG call_count, sub1_count, sub2_count
COMMON (into) LONG sub3_count, sub4_count
```

When you explicitly declare an array, VAX BASIC allows you to specify both upper and lower bound values. The value you supply as the upper bound determines the maximum subscript value for a given dimension, whereas the value you supply for the lower bound determines the minimum subscript value for a given dimension.

For more information on specifying bounds with the COMMON statement, see the *VAX BASIC Reference Manual* and Chapter 8 in this manual.

9.7.2 The MAP Statement

The MAP statement, like the COMMON statement, creates a named area of static storage. However, if a program module contains multiple maps with the same name, the maps are overlaid on the same area of storage, rather than being concatenated.

When used with the MAP clause of the OPEN statement, the storage allocated by the MAP statement becomes the record buffer for that file. Variables in the MAP statement correspond to fields in the file's records.

A map item can be one of the following:

- A numeric variable
- A numeric array
- A fixed-length string variable
- An array of fixed-length strings
- A RECORD instance
- A FILL item

When you explicitly declare an array, VAX BASIC allows you to specify both upper and lower bound values. The value you supply as the upper bound determines the maximum subscript value for a given dimension, whereas the value you supply for the lower bound determines the minimum subscript value for a given dimension.

For more information on specifying bounds with the MAP statement, see the *VAX BASIC Reference Manual*, and Chapter 8 in this manual.

9.7.2.1 Single Maps

You associate a map with a record buffer by referencing the map in the OPEN statement.

The MAP statement must appear before any reference to map variables. For example, the following program uses map variables to access fields in payroll records. Changes to map variables do not change the actual records in the file. To transfer the changed variables to the file, you must use the PUT or UPDATE statement. For more information, see Chapter 15.

Example

```
WHEN ERROR USE eof_handler
DECLARE INTEGER CONSTANT EOF = 11

MAP (PAYROL) STRING emp_name, LONG wage_class,     &
                  STRING sal_rev_date, SINGLE tax_ytd

OPEN "payroll.dat" FOR INPUT AS FILE #4%           &
                      ,ORGANIZATION SEQUENTIAL     &
                      ,ACCESS READ                 &
                      ,MAP PAYROL

OPEN "payrol.new" FOR OUTPUT AS FILE #5%           &
             ,ORGANIZATION SEQUENTIAL              &
             ,ACCESS WRITE                         &
             ,MAP payrol

PRINT "PAYROLL VERIFICATION"


 get_loop:
     WHILE 1% = 1%
         GET #4
         PRINT emp_name, wage_class, sal_rev_date, tax_ytd
         PRINT "YOU CAN CHANGE:"
         PRINT "1. EMPLOYEE NAME"
         PRINT "2. WAGE CLASS"
         PRINT "3. REVIEW DATE"
         PRINT "4. TAX YEAR-TO-DATE"
         PRINT "5. DONE"

 read_loop:
        WHILE 1% = 1%
         INPUT "CHANGES? ANSWER WITH YES OR NO" ; chng$
         IF chng$ = "NO" THEN ITERATE get_loop
                  ELSE INPUT "NUMBER" ;number%

         END IF
```

```
            SELECT number%
            CASE 1
                 INPUT "EMPLOYEE NAME"; emp_name
            CASE 2
                 INPUT "WAGE CLASS"; wage_class
            CASE 3
                 INPUT "REVIEW DATE";sal_rev_date
            CASE 4
                 INPUT "TAX YEAR-TO-DATE"; tax_ytd
            CASE 5
                 EXIT read_loop
            CASE ELSE
                 PRINT "Invalid response -- please try again"
            END SELECT
           NEXT
           PUT #5
        NEXT
END WHEN
HANDLER eof_handler
   IF ERR = EOF
     THEN
            PRINT "End of file"
     ELSE
            EXIT HANDLER
   END IF
END HANDLER
END
```

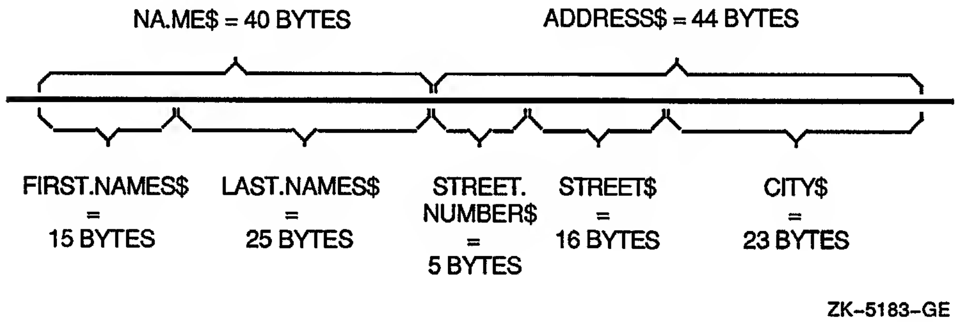
9.7.2.2 Multiple Maps

When a program contains more than one map with the same name, the storage allocated by these MAP statements is overlaid. This technique is useful for manipulating strings. Figure 9–2 illustrates this.

When you use more than one map to access a record buffer, VAX BASIC uses the size of the largest map to determine the size of the record. (The RECORDSIZE clause of the OPEN statement can override this map-defined record size. For more information, see Chapter 15.)

You can also use multiple maps to interpret numeric data in more than one way. The following example creates a map area named *barray*. The first MAP statement allocates 26 bytes of storage in the form of an integer BYTE array. The second MAP statement defines this same storage as a 26-byte string named *ABC*. When the FOR...NEXT loop executes, it assigns values corresponding to the ASCII values for the uppercase letters A through Z.

Figure 9–2: Multiple Maps



Example

```
MAP (barray) BYTE alphabet(25)
MAP (barray) STRING ABC = 26
FOR I% = 0% TO 25%
    alphabet(I%) = I% + 65%
NEXT I%
PRINT ABC
END
```

Output

```
ABCDEFGHIJKLMNOPQRSTUVWXYZ
```

9.7.3 FILL Items

FILL items reserve space in map and common blocks and in record buffers accessed by MOVE or REMAP statements. Thus, FILL items mask parts of the record buffer and let you skip over fields and reserve space in or between data elements.

FILL formats are available for all data types. Table 9–3 summarizes the FILL formats and their default allocations if no data type is specified.

Table 9–3: FILL Item Formats, Representations, and Default Allocations

FILL Format	Representation	Bytes Used
FILL	Floating-point	4, 8, or 16
FILL(n)	n floating-point elements	4n, 8n, or 16n
FILL%	Integer (BYTE, WORD, or LONG)	1, 2, or 4
FILL%(n)	n integer elements	1n, 2n, or 4n
FILL$	String	16
FILL$(n)	n string elements	16n
FILL$ = m	String	m
FILL$(n) = m	n string elements, m bytes each	m * n

NOTE

> In the applicable formats of FILL, *n* represents a repeat count, not an array subscript. FILL(*n*), for example, represents *n* real elements, not n+1.

You can also use data type keywords with FILL and optionally data type suffixes. The data type and storage requirements are those of the last data type specified. For example:

```
MAP (QED) STRING A, FILL$=24, LONG SSN, FILL%, REAL SAL, FILL(5)
```

This MAP statement uses data type keywords to reserve space for:

- A 16-character string variable A.
- Twenty-four bytes of padding.
- One LONG variable, SSN.
- Four bytes of padding.
- One REAL variable, SAL.
- Space for five floating-point numbers. This requires 10, 20, or 80 bytes of padding, depending on the default size for floating-point numbers.

You can specify user-defined data types (RECORD names) for FILL items. For instance, in the following example, the first line defines a RECORD of data type *X*. The MAP statement contains a fill item of this data type, thus reserving space in the buffer for one RECORD of type *X*.

```
RECORD X
   REAL Y1, Y2(10)
END RECORD X
MAP (QED) X FILL
```

See Chapter 10 for more information on the RECORD statement.

9.7.4 Using COMMON and MAP in Subprograms

The COMMON and MAP statements create a block of storage called a PSECT. This common or map storage block is accessible to any subprogram. A VAX BASIC main program and a subprogram can share such an area by referencing the same common or map name.

For instance, the following example contains common blocks that define:

- A 16-character string field called *A* by the main program and *X* by the subprogram
- A 10-character string field called *B* by the main program and *Z* by the subprogram
- A 4-byte integer field called *C* by the main program and *Y* by the subprogram

```
!In a main program
COMMON (A1) STRING A, B = 10, LONG C
    .
    .
    .
!In a subprogram
COMMON (A1) STRING X, Z = 10, LONG Y
```

If a subprogram defines a common or map area with the same name as a common or map area in the main program, it overlays the common or map defined in the main program.

Multiple COMMON statements with the same name behave differently depending on whether these statements are in the same program module. If they are in the same program module, then the storage for each common area is concatenated. However, if they are in different program units, then the common areas overlay the same storage. The following COMMON statements are in the same program module; therefore, they are concatenated in a single PSECT. The PSECT contains two 32-byte strings.

```
COMMON (XYZ) STRING A = 32
COMMON (XYZ) STRING B = 32
```

In contrast, the following COMMON statements are in different program modules, and thus overlay the same storage. Therefore, the PSECT contains one 32-byte string, called *A* in the main program and *B* in the subprogram.

```
!In the main program
COMMON (XYZ) STRING A = 32
    .
    .
    .
!In the subprogram
COMMON (XYZ) STRING B = 32
```

Although you can redefine the storage in a common section when you access it from a subprogram, you should generally not do so. Common areas should contain exactly the same variables in all program modules. To make sure of this, you should use the %INCLUDE directive, as shown in the following example.

Example

```
COMMON (SHARE) WORD emp_num,                  &
            DECIMAL (8,0) salary,             &
            STRING wage_class = 2
    .
    .
    .
!In the main program
%INCLUDE "COMMON.BAS"
    .
    .
    .
!In the subprogram
%INCLUDE "COMMON.BAS"
```

If you use the %INCLUDE directive, you can lessen the chance of a typographical error appearing in your program. For more information on using the %INCLUDE directive, see Chapter 18.

If you must redefine the variables in a PSECT, you should use the MAP statement or a record with variants for each overlay. When you use the MAP statement, use the %INCLUDE directive to create identical maps before redefining them, as shown in the following example. The map defined in MAP.BAS is included in both program modules as a 40-byte string. This map is redefined in the subprogram, allowing the subprogram to access parts of this string.

Example

```
MAP (REDEF) STRING full_name = 40
    .
    .
    .
!In the main program
%INCLUDE "MAP.BAS"
    .
    .
    .
!In the subprogram
%INCLUDE "MAP.BAS"
MAP (REDEF) STRING first_name=15, MI=1, last_name=24
```

9.8 Dynamic Mapping

Dynamic mapping lets you redefine the position of variables in a static storage area. This storage area can be either a map name or a previously declared static string variable. Dynamic mapping requires three VAX BASIC statements:

- A declarative statement, such as a MAP statement, allocating a fixed-length storage area
- A MAP DYNAMIC statement, naming the variables whose positions can change at run time
- A REMAP statement, specifying the new positions of the variables named in the MAP DYNAMIC statement

The MAP DYNAMIC statement does not affect the amount of storage allocated. The MAP DYNAMIC statement causes VAX BASIC to create internal pointers to the variables and array elements. Until your program executes the REMAP statement, the storage for each variable and each array element named in the MAP DYNAMIC statement starts at the beginning of the map storage area.

The MAP DYNAMIC statement is nonexecutable. With this statement, you cannot specify a string length. All string items have a length of zero until the program executes a REMAP statement.

The REMAP statement specifies the new positions of variables named in the MAP DYNAMIC statement. That is, it causes VAX BASIC to change the internal pointers to the data. Because the REMAP statement is executable, it can redefine the pointer for a variable or array element each time the REMAP statement is executed.

With the MAP DYNAMIC statement, you can specify either a map name or a previously declared static string variable. When you specify a map name, a MAP statement with the same map name must lexically precede the MAP DYNAMIC statement.

In the following example, the MAP statement creates a storage area and names it *emp_buffer*. The MAP DYNAMIC statement specifies that the positions of variables *emp_name* and *emp_address* within the map area, can be dynamically defined with the REMAP statement.

Example

```
DECLARE LONG CONSTANT emp_fixed_info = 4 + 9 + 2
MAP (emp_buffer) LONG badge,                    &
                 STRING social_sec_num = 9,     &
                 BYTE name_length,              &
                      address_length,           &
                      FILL (60)

MAP DYNAMIC (emp_buffer) STRING emp_name,       &
                                emp_address

WHILE 1%
GET #1
REMAP (emp_buffer) STRING FILL = emp_fixed_info,             &
                               emp_name = name_length,       &
                               emp_address = address_length

NEXT
```

At the start of program execution, the storage for *badge* is the first 4 bytes of *emp_buffer*, the storage for *social_sec_num* is equal to 9 bytes and together *name_length* and *address_length* are equal to 2 bytes. The FILL keyword reserves 60 additional bytes of storage. The MAP DYNAMIC statement defines the variables *emp_name* and *emp_address* whose positions and lengths will change at run time. When executed, the REMAP statement defines the FILL area to be equal to *emp_fixed_info* and defines the positions and lengths of *emp_name* and *emp_address*.

When you specify a static string variable, it must be either a variable declared in a MAP or COMMON statement or a parameter declared in a SUB, FUNCTION, PICTURE, or DEF. The actual parameter passed to the procedure must be a static string variable defined in a COMMON, MAP, or RECORD statement.

The following example shows the use of a static string variable as a parameter declared in a SUB. The MAP DYNAMIC statement specifies the input parameter, *input_rec*, as the string to be dynamically defined with the REMAP statement. In addition, the MAP DYNAMIC statement specifies a string array *A* whose elements will point to positions in *input_rec* after the REMAP statement is executed. The REMAP statement defines the length and position of each element contained in array *A*. The FOR...NEXT loop

then assigns each element contained in array *A* into array *item*, the target array.

Example

```
SUB deblock (STRING input_rec, STRING item())
 MAP DYNAMIC (input_rec) STRING A(1 TO 3)
 REMAP (input_rec) &
     A(1) = 5, &
     A(2) = 3, &
     A(3) = 4
 FOR I = LBOUND(A) TO UBOUND(A)
   item(I) = A(I)
 NEXT I
END SUB
```

Note that dynamic map variables are local to the program module in which they reside. Therefore, REMAP only affects how that module views the buffer.

For more information on using the MAP DYNAMIC and REMAP statements, see the *VAX BASIC Reference Manual*.

Chapter 10

Creating and Using Data Structures

A data structure is a collection of data items that can contain elements or components of different data types.

The RECORD statement lets you create your own data structures. You use the RECORD statement to create a pattern of a data structure, called the *RECORD template*. Once you have created a template, you use it to declare an *instance* of the RECORD, that is, a *RECORD variable*. You declare a RECORD variable just as you declare a variable of any other type: with the DECLARE statement or another declarative statement. A RECORD instance is a variable whose structure matches that of the RECORD template.

Remember that the RECORD statement does not create any variables. It merely creates a template, or user-defined data type, that you can then use to create variables.

This chapter describes how to create and use data structures.

10.1 The RECORD Statement

The RECORD statement names and defines a data structure. Once a data structure (or RECORD) has been named and defined, you can use that RECORD name anywhere that you can use a VAX BASIC data type keyword. You build the data structure using:

- Variables of any valid VAX BASIC data type
- RECORD variables of previously defined RECORD data types
- Any combination of the two

The following example creates a RECORD template called *Employee*. *Employee* is a data structure that contains one LONG integer, one 10-character string, one 20-character string, and one 11-character string.

Example

```
RECORD Employee
  LONG Emp_number
  STRING First_name = 10
  STRING Last_name = 20
  STRING Soc_sec_number = 11
END RECORD Employee
```

To create instances of this data structure, you use declarative statements. For instance, in the following example, the first DECLARE statement creates a variable named *Emp_rec* of data type *Employee*. The second DECLARE statement creates a one-dimensional array, named *Emp_array*, that contains 1001 instances of the *Employee* data type.

Example

```
DECLARE Employee Emp_rec
DECLARE Employee Emp_array (1000)
```

Any reference to a RECORD component must contain the name of the RECORD instance (that is, the name of the declared variable) and the name of the elementary RECORD component you are accessing, separated by two colons (::). For example, the following program assigns values to an instance of the *Employee* RECORD template.

Example

```
! Record Template

RECORD Employee

  LONG   Emp_number
  STRING First_name = 10
  STRING Last_name  = 20
  STRING Soc_sec_number = 11

END RECORD Employee
! Declarations

DECLARE Employee Emp_rec

DECLARE STRING Social_security

! Program logic starts here.
```

```
INPUT 'Employee number'; Emp_rec::Emp_number
INPUT 'First name';      Emp_rec::First_name
INPUT 'Last name';       Emp_rec::Last_name
INPUT 'Social security'; Social_security
IF Social_security <> ""
THEN
   Emp_rec::Soc_sec_number = Social_security
END IF
PRINT
PRINT "Employee number is: "; Emp_rec::Emp_number
PRINT "First name is: ";      Emp_rec::First_name
PRINT "Last name is: ";       Emp_rec::Last_name
PRINT "Social security is: "; Emp_rec::Soc_sec_number
END
```

When you access an array of RECORD instances, the array subscript should immediately follow the name of the RECORD variable. The following example shows an array of RECORD instances.

Example

```
! Record Template

RECORD Employee

  LONG   Emp_number
  STRING First_name = 10
  STRING Last_name  = 20
  STRING Soc_sec_number = 11

END RECORD
! Declarations

DECLARE Employee Emp_array ( 10 )

DECLARE INTEGER Index

DECLARE STRING Social_security

! Program logic starts here.

FOR Index = 0 TO 10

  PRINT
  INPUT 'Employee number'; Emp_array(Index)::Emp_number
  INPUT 'First name';      Emp_array(Index)::First_name
  INPUT 'Last name';       Emp_array(Index)::Last_name
  INPUT 'Social security'; Social_security
  IF Social_security <> ""
  THEN
     Emp_array(Index)::Soc_sec_number = Social_security
  END IF
NEXT Index

FOR Index = 0 TO 10

PRINT
PRINT "Employee number is: "; Emp_array(Index)::Emp_number
PRINT "First name is: ";      Emp_array(Index)::First_name
PRINT "Last name is: ";       Emp_array(Index)::Last_name
PRINT "Social security is: "; Emp_array(Index)::Soc_sec_number
```

```
NEXT Index
END
```

You can have a RECORD that contains an array. When you declare arrays, VAX BASIC allows you to specify both lower and upper bounds.

Example

```
RECORD Grade_record

  STRING     Student_name = 30
  INTEGER    Quiz_scores (1 TO 10)    ! Array to hold ten quiz grades.

END RECORD
! Declarations

DECLARE Grade_record Student_grades ( 5 )

!The Student_grades array holds information on six students
!(0 through 5), each of whom has ten quiz grades (1 through 10).

DECLARE INTEGER I,J
!Program logic starts here.

FOR I = 0 TO 5       !This loop executes once for each student.

  PRINT
  INPUT 'Student name'; Student_grades(I)::Student_name

    FOR J = 1 TO 10  !This loop executes ten times for each student.

      PRINT 'Score for quiz number'; J
      INPUT Student_grades(I)::Quiz_scores(J)

    NEXT J
NEXT I

FOR I = 0 TO 5

  PRINT
  PRINT 'Student name: '; Student_grades(I)::Student_name

    FOR J = 1 TO 10

      PRINT 'Score for quiz number'; J; ": ";
      PRINT Student_grades(I)::Quiz_scores(J)

    NEXT J

NEXT I

END
```

Because any reference to a component of a RECORD instance must begin with the name of the RECORD instance, RECORD component names need not be unique in your program. For example, you can have a RECORD component called *First_name* in any number of different RECORD statements. References to this component are unambiguous because every RECORD component reference must specify the record instance in which it resides.

10.1.1 Grouping RECORD Components

A RECORD component can consist of a named group of instances, identified with the keyword GROUP. You use GROUP to refer to a collection of RECORD components, or to create an array of components that have different data types. The GROUP name can be followed by a list of upper and lower bounds, which define an array of the GROUP components. GROUP is valid only within a RECORD block.

The declarations between the GROUP statement and the END GROUP statement are called a GROUP block.

For instance, the following example declares a RECORD template of data type *Yacht*. *Yacht* is made up of two groups: *Type_of_yacht* and *Specifications*. Each of these groups is composed of elementary RECORD components. VAX BASIC also allows groups within other groups.

Example

```
RECORD Yacht

  GROUP Type_of_yacht
    STRING Manufacturer = 10
    STRING Model = 10
  END GROUP Type_of_yacht
  GROUP Specifications
    STRING Rig = 6
    STRING Length_over_all = 3
    DECIMAL(5,0) Displacement
    DECIMAL(2,0) Beam
    DECIMAL(7,2) Price
  END GROUP Specifications

END RECORD Yacht
```

10.1.2 RECORD Variants

In some cases, it is useful to have different record components overlay the same record field, in much the same way that multiple maps can overlay the same storage. Such an overlay is called a *RECORD variant*. You use the keywords VARIANT and CASE to set up RECORD variants.

The following example creates a RECORD template for any of three kinds of boats.

Example

```
RECORD Boat

  STRING Make  = 10
  STRING Model = 10
  STRING Type_of_boat = 1     ! This field contains the value S, P, or C.
                              ! Value S causes the record instance to be
                              ! interpreted as describing a sailboat, value
                              ! P as describing a powerboat, and value C as
                              ! describing a canoe.
  VARIANT

  CASE      ! Sailboats

    STRING Rig   = 20
  CASE      ! Powerboats

    WORD    Horsepower

  CASE      ! Canoes

    WORD    Length
    WORD    Weight

  END VARIANT

END RECORD
```

The SELECT...CASE statement makes it easy to access one of several possible RECORD variants in a particular RECORD instance. A RECORD component outside the overlaid fields usually determines which RECORD variant is being used in a particular reference; in this case the determining RECORD component is *Type_of_boat*. You can use this component in the SELECT expression.

Example

```
! Declarations

DECLARE Boat My_boat

! Main program logic starts here

   .
   .
   .
Input_boat_information:

  INPUT 'Make of boat'; My_boat::Make
  INPUT 'Model';        My_boat::Model
  PRINT 'Type of boat (S = Sailboat, P = Powerboat, C = Canoe)';
  INPUT My_boat::Type_of_boat
  SELECT My_boat::Type_of_boat

  CASE "S"

    INPUT 'Sail rig'; My_boat::Rig

  CASE "P"

    INPUT 'Horsepower'; My_boat::Horsepower
```

```
  CASE "C"

     INPUT 'Length'; My_boat::Length
     INPUT 'Weight'; My_boat::Weight

  CASE ELSE

     PRINT "Invalid type of boat, please try again."

  END SELECT
```

The value of the *Type_of_boat* component determines the format of the variant part of the record.

The following example is a slightly more complex version of the same type of procedure. This program prompts for the RECORD instance components in each variant. When the user responds to the "Wage Class" prompt, the program branches to one of three CASE blocks depending on the value of *Wage_class*.

Example

```
!Record templates

RECORD Emp_wage_class

  STRING Emp_name = 30           ! Employee name string.

  STRING Street = 15             !
  STRING City = 20               ! These components make up the
  STRING State = 2               ! employee address field.
  DECIMAL(5,0) Zip               !

  STRING Wage_class = 1
  VARIANT

    CASE

      GROUP Hourly                       ! Hourly workers.

        DECIMAL(4,2) Hourly_wage         ! Hourly wage rate.
        SINGLE Regular_pay_ytd           ! Regular pay year-to-date.
        SINGLE Overtime_pay_ytd          ! Overtime pay year-to-date.

      END GROUP Hourly
    CASE

      GROUP Salaried                     ! Salaried workers.

        DECIMAL(7,2) Yearly_salary       ! Yearly salary.
        SINGLE Pay_ytd                   ! Pay year-to-date.

      END GROUP Salaried
    CASE

      GROUP Executive                    ! Executives.

        DECIMAL(8,2) Yearly_salary       ! Yearly salary.
        SINGLE Pay_ytd                   ! Pay year-to-date.
        SINGLE Expenses_ytd              ! Expenses year-to-date.

      END GROUP Executive
```

```
  END VARIANT

END RECORD
! Declarations:

  DECLARE Emp_wage_class Emp

! Main Program logic starts here.

LINPUT "Name"; Emp::Emp_name             ! Use LINPUT statements for
LINPUT "Street"; Emp::Street             ! string fields so the entire
                                         ! string is assigned to the
LINPUT "State"; Emp::State               ! variable.
INPUT  "Zip Code"; Emp::Zip
LINPUT "Wage Class"; Emp::Wage_class
SELECT Emp::Wage_class

CASE "A"
  INPUT 'Rate';Emp::Hourly_wage
  INPUT 'Regular pay';Emp::Regular_pay_ytd
  INPUT 'Overtime pay';Emp::Overtime_pay_ytd

CASE "B"
  INPUT 'Salary';Emp::Salaried::yearly_salary
  INPUT 'Pay YTD';Emp::Salaried::pay_ytd

CASE "C"
  INPUT 'Salary';Emp::Executive::yearly_salary
  INPUT 'Pay YTD';Emp::Executive::pay_ytd
  INPUT 'Expenses';Emp::Expenses_ytd

END SELECT
```

Variant fields can appear anywhere within the RECORD instance. When you use RECORD variants, you imply that any RECORD instance can contain any one of the listed variants. Therefore, if each variant requires a different amount of space, VAX BASIC uses the case that requires the most storage to determine the space allocated for each RECORD instance.

10.1.3 Accessing RECORD Components

To access a particular elementary component within a RECORD that contains other groups, you use the name of the declared RECORD instance, the group name (or group names, if groups are nested), and the elementary component name, each separated by double colons (::).

In the following example, the PRINT statement displays the *Rig* component in the *Specifications* group in the variable named *My_yacht*. The RECORD instance name qualifies the group name and the group name qualifies the elementary RECORD component. The elementary component name, qualified by all intermediate group names, and by the RECORD instance name, is called a *fully qualified* component. The full qualification of a component is called a *component path name*.

Example

```
DECLARE Yacht My_yacht
   .
   .
   .
PRINT My_yacht::Specifications::Rig
```

Because it is cumbersome to specify the entire component path name, VAX BASIC allows *elliptical references* to RECORD components. GROUP names are optional in the component path name unless:

- A RECORD contains more than one component with the same name
- The GROUP is an array

The rules for using elliptical references are as follows:

- You must always specify the RECORD instance, that is, the name of the declared variable.
- You must always specify any dimensioned group.
- You may omit any other intermediate component names.
- You must specify the final component name.

The following example shows that using the complete component path name is valid but not required. The assignment statement uses the fully-qualified component name; the PRINT statement uses an elliptical reference to the same component, omitting *Extended_family* and *Nuclear_family* GROUP names. Note that the *Children* GROUP name *is* required because the GROUP is an array; the elliptical reference to this component must include the desired array element, in this case the second element of the *Children* array.

Example

```
! RECORD templates:

RECORD Family

  GROUP Extended_family

    STRING Grandfather(1) = 30    ! Two-element fixed-length string
    STRING Grandmother(1) = 30    ! arrays for the names of maternal
                                  ! and paternal grandparents.
    GROUP Nuclear_family

      STRING Father = 30          ! Fixed-length strings for the names
      STRING Mother = 30          ! of parents.
        GROUP Children (10)       ! An 11-element array for the names and
                                  ! gender of children.
          STRING Kid = 10
          STRING Gender = 1
```

```
        END GROUP Children

    END GROUP Nuclear_family

  END GROUP Extended_family

END RECORD
! Declarations

DECLARE Family My_family
! Program logic starts here.

My_family::Extended_family::Nuclear_family::Children(1)::Kid = "Johnny"

PRINT My_family::Children(1)::Kid

END
```

Output

```
Johnny
```

Example

```
! RECORD Templates.

RECORD Test

  INTEGER Test_integers(2)      ! 3-element array of integers.

  GROUP Group_1                 ! Single GROUP containing:

    REAL   My_number            ! a real number and
    STRING Group_1_string       ! a 16-character (default) string

  END GROUP
  GROUP Group_2(5)              ! A 6-element GROUP, each element containing:

    INTEGER My_number           ! an integer and
    DECIMAL Group_2_decimal     ! a DECIMAL number.

  END GROUP

END RECORD
! Declarations

DECLARE Test Array_of_test(10)   ! Create an 11-element array of type Test...
DECLARE Test Single_test         ! ...and a separate single instance of type
                                 ! Test.
```

The minimal reference to the string *Group_1_string* in RECORD instance *Array_of_test* is as follows:

```
Array_of_test(i)::Group_1_string
```

In this case, *i* is the subscript for array *Array_of_test*. Because the RECORD instance is itself an array, the reference must include a specific array element.

Because *Single_test* is not an array, the minimal reference to string *Group_1_string* in RECORD instance *Single_test* is as follows:

```
Single_test::Group_1_string
```

The minimal reference for the REAL variable *My_number* in GROUP *Group_1* in RECORD instance *Array_of_test* is as follows:

```
Array_of_test(i)::Group_1::My_number
```

Here, *i* is the subscript for array *Array_of_test*. The minimal reference to the REAL variable *My_number* in RECORD instance *Single_test* is as follows:

```
Single_test::Group_1::My_number
```

Because there is a variable named *My_number* in groups *Group_1* and *Group_2*, you must specify either *Group_1::My_number* or *Group_2(i)::My_number*. In this case, extra component names are required to resolve an otherwise ambiguous reference.

The minimal reference to the DECIMAL variable *Group_2_decimal* in RECORD instances *Array_of_test* and *Single_test* are the fully qualified references. In the following examples, *i* is the subscript for array *Array_of_test* and *j* is an index into the group array *Group_2*. Even though *Group_2_decimal* is a unique component name within RECORD instance *Single_test*, the element of array *Group_2* must be specified. In this case the extra components must be specified because each element of GROUP *Group_2* contains a component named *Group_2_decimal*.

```
Array_of_test(i)::Group_2(j)::Group_2_decimal
```

```
Single_test::Group_2(j)::Group_2_decimal
```

You can assign all the values from one RECORD instance to another RECORD instance, as long as the RECORD instances are identical except for names.

In the following example, RECORD instances *First_test1*, *Second_test1*, and the individual elements of array *Array_of_test1* have the same form: an array of four groups, each of which contains a 10-byte string variable, followed by a REAL variable, followed by an INTEGER variable. Any of these RECORD instances can be assigned to one another.

Example

```
!RECORD Templates

RECORD Test1

  GROUP Group_1(4)

    STRING   My_string_1 = 10
    REAL     My_real_1
    INTEGER  My_integer_1

  END GROUP

END RECORD

RECORD Test2

  GROUP Group_2

    STRING  My_string_2 = 10
    REAL    My_real_2
    INTEGER My_integer_2

  END GROUP

END RECORD
RECORD Test3

  STRING   My_string_3 = 10
  REAL     My_real_3
  INTEGER  My_integer_3

END RECORD
!Declarations

DECLARE Test1 First_test1,          &
              Second_test1,         &
              Array_of_test1(3)

DECLARE Test2 First_test2

DECLARE Test3 First_test3,          &
              Array_of_test3(10)
!Program logic starts here

! A single RECORD instance is assigned to another single instance

First_test1 = Second_test1

! An array element is assigned to a single instance

Second_test1 = Array_of_test1(2)

! And vice versa

Array_of_test1(2) = Second_test1
```

Further, you can assign values from single RECORD instances to groups contained in other instances.

In the following example, *Array_of_test1* and *First_test1* do not have the same form because *Array_of_test1* is an array of RECORD *Test1* and *First_test1* is a single instance of RECORD *Test1*. Therefore, *First_test1* and *Array_of_test1* cannot be assigned to one another.

Example

```
! A single instance is assigned to one group

Array_of_test1(3)::Group_1(2) = First_test1

! An array element is assigned a value from
! a group contained in another array instance
Array_of_test3(5) = Array_of_test1(3)::Group_1(3)
```

The examples shown in this chapter explain the mechanics of using data structures. See Chapter 14 for more information about using data structures as parameters. See Chapter 15 for more information about using data structures for file input and output.

Chapter 11

Program Control

VAX BASIC normally executes statements sequentially. *Control statements* let you change this sequence of execution. VAX BASIC control statements can alter the sequence of program execution at several levels:

- Statement modifiers control the execution of a single statement.
- Loops or decision blocks control the execution of a block of statements.
- Branching statements such as GOTO and ON GOTO pass control to statements or local subroutines.
- The EXIT and ITERATE statements explicitly control loops or decision blocks.
- The SLEEP, WAIT, STOP and END control statements suspend or halt the execution of your entire program.

This chapter describes all the VAX BASIC control statements.

11.1 Statement Modifiers

Statement modifiers are control structures that operate on a single statement. Statement modifiers let you execute a statement conditionally or create an implied loop. VAX BASIC has five statement modifiers: IF, UNLESS, FOR, UNTIL, and WHILE.

A statement modifier affects only the statement immediately preceding it. You can modify only executable statements; declarative statements cannot be modified.

11.1.1 The IF Modifier

The IF modifier tests a conditional expression. If the conditional expression is true, VAX BASIC executes the statement. If it is false, VAX BASIC does not execute the modified statement but continues execution at the next program statement. The following is an example of a statement using the IF modifier:

```
PRINT A IF (A < 5)
```

11.1.2 The UNLESS Modifier

The UNLESS modifier tests a conditional expression. VAX BASIC executes the modified statement only if the conditional expression is false. Like the IF modifier, the UNLESS modifier operates on a single statement:

```
PRINT A UNLESS (A < 5)
```

This is equivalent to the following:

```
PRINT A IF A >= 5
```

11.1.3 The FOR Modifier

The FOR modifier creates a loop on a single line. The following is an example of an implied loop created by a FOR modifier:

```
A = A + 1 FOR I% = 1% TO 10%
```

11.1.4 The UNTIL Modifier

The UNTIL modifier, like the FOR modifier, creates a single-line loop. However, instead of using a formal loop variable, you specify the terminating condition with a conditional expression. The modified statement executes repeatedly as long as the condition is false. For example:

```
B = B + 1 UNTIL (A  - B) < 0.0001
```

Because of precision limitations, you should not use real number calculations in UNTIL loops. For example:

```
Z = Z + 1 UNTIL Z/5 = 100
```

Because *Z*/5 may never exactly equal 100, the loop could execute indefinitely.

11.1.5 The WHILE Modifier

The WHILE modifier repeats a statement as long as a conditional expression is true. Like the UNTIL and FOR modifiers, it lets you create single-line loops. In the following example, VAX BASIC replaces the value of *A* with *A*/2 as long as the absolute value of *A* is greater than 1/10. Note that you can inadvertently create an infinite loop if the terminating condition is never reached.

```
A = A / 2 WHILE ABS(A) > 0.1
```

11.1.6 Nesting Modifiers

You can append more than one modifier to a statement. This is called *nesting* modifiers. VAX BASIC evaluates nested modifiers from right to left. If the test of the rightmost modifier fails, control passes to the next statement, not to the preceding modifier on the same line.

In the following example, VAX BASIC first tests the rightmost modifier of the first PRINT statement. Because this condition is false, VAX BASIC executes the following PRINT statement and tests the rightmost modifier. Because this condition is met, VAX BASIC tests the leftmost modifier of the same PRINT statement. This condition, however, is not met. Therefore, VAX BASIC executes the following PRINT statement. Because both conditions are met in the third PRINT statement, VAX BASIC prints the value of *C*.

Example

```
A = 5
B = 10
C = 15

PRINT "A =";A IF A = 5 UNLESS C = 15
PRINT "B =";B UNLESS C = 15 IF B = 10
PRINT "C =";C IF B = 10 UNLESS C = 5
END
```

Output

```
C = 15
```

11.2 Loops

Loops allow you to repeat the execution of a set of statements. This set of statements is called a *loop block*. There are three types of VAX BASIC program loops:

- FOR...NEXT
- WHILE...NEXT
- UNTIL...NEXT

If you know how many times you want a loop to execute, that is, the number of *iterations*, you can use a FOR...NEXT loop. If you do not know the exact number of iterations when the loop begins execution, you can use either a WHILE...NEXT or an UNTIL...NEXT loop.

Note that all these types of loops can be nested, that is, lexically located one inside another.

11.2.1 FOR...NEXT Loops

In a FOR...NEXT loop, you specify a loop control variable (the loop index) that determines the number of loop iterations. This number must be a scalar (unsubscripted) variable. When VAX BASIC begins execution of a FOR...NEXT loop, the starting and ending values of the loop control variable are known.

The FOR statement assigns the control variable a starting value and a terminating value. You can use the optional STEP clause to specify the amount to be added to the loop control variable after each loop iteration.

When a FOR loop block executes, the VAX BASIC compiler does the following:

1. Evaluates the starting value and assigns it to the control variable.
2. Evaluates the ending value and the step value and assigns these results to temporary storage locations.
3. Tests whether the ending value has been exceeded. If the ending value has already been exceeded, VAX BASIC executes the statement following the NEXT statement. If the ending value has not been exceeded, VAX BASIC executes the statements in the loop.

4. Adds the step value to the control variable and transfers control to the FOR statement, which tests whether the ending value has been exceeded. Steps 3 and 4 are repeated until the ending value is exceeded.

Note that VAX BASIC performs the test before the loop executes. When the control variable exceeds the ending value, VAX BASIC exits the loop, and then subtracts the step value from the control variable. This means that after loop execution, the value of the control variable is the value last used in the loop, not the value that caused loop termination. If the starting value is greater than the ending value, and the step value is positive, the loop will not execute.

Example 1 assigns the values 1 through 10 to consecutive array elements 1 through 10 of *New_array*, whereas Example 2 assigns consecutive multiples of 2 to the odd-numbered elements of *New_array*.

Example 1

```
FOR I% = 1% TO 10%
    New_array(I%) = I%
NEXT I%
```

Example 2

```
FOR I% = 1% TO 10% STEP 2
    New_array(I%) = I% + 1%
NEXT I%
```

Note that the starting, ending, and step values can be *run-time expressions*. You can have VAX BASIC calculate these values when the program runs, as opposed to using a constant value. For instance, the following example assigns sales information to array *Sales_data*. The number of iterations depends on the value of the variable *Days_in_month*, which represents the number of days in that particular month.

Example

```
FOR I% = 1% TO Days_in_month
    Sales_data(I%) = Quantity_sold
NEXT I%
```

Because the starting, ending, and step values can be numeric expressions, they are not evaluated until the program runs. This means that you can have a FOR...NEXT loop that does not execute. The following example prompts the user for the starting, ending, and step values for a loop, and then tries to execute that loop. The loop executes zero times because it is impossible to go from 0 to 5 using a step value of –1.

Example

```
counter% = 0%

INPUT "Start"; start%
INPUT "Finish"; finish%
INPUT "Step value"; step_val%

FOR I% = start% TO finish% STEP step_val%
    counter% = counter% + 1%
NEXT I%

PRINT "This loop executed"; counter%; "times."
```

Output

```
Start? 0
Finish? 5
Step value? -1
This loop executed 0 times.
```

Whenever possible, you should use integer variables to control the execution of FOR...NEXT loops because some decimal fractions cannot be represented exactly in a binary computer, and the calculation of floating-point control variables is subject to this inherent imprecision.

In the following example, the first loop uses an integer control variable while the second uses a floating-point control variable. The first loop executes 100 times and the second 99 times. After the ninety-ninth iteration of the second loop, the internal representation of the value of *Floating_point_variable* exceeds 10 and VAX BASIC exits the loop. Because the first loop uses integer values to control execution, VAX BASIC does not exit the loop until *Integer_variable* equals 100.

Example

```
Loop_count_1 = 0%
Loop_count_2 = 0%

FOR Integer_variable = 1% to 100% STEP 1%
    Loop_count_1 = Loop_count_1 + 1%
NEXT Integer_variable

FOR Floating_point_variable = 0.1 to 10 STEP 0.1
    Loop_count_2 = Loop_count_2 + 1%
NEXT Floating_point_variable

PRINT "Integer loop count:"; Loop_count_1
PRINT "Integer loop end  :"; Integer_variable
PRINT "Real loop count:   "; Loop_count_2
PRINT "Real loop end:     "; Floating_point_variable
```

Output

```
Integer loop count:  100
Integer loop end:    100
Real loop count:     99
Real loop end:       9.9
```

If you need to use floating-point values in a loop, you should initialize a floating-point variable and increment it within the loop.

Example

```
Real_counter = 0.1
Count_loop:
FOR Integer_variable = 1% TO 100000%
    Real_counter = Real_counter + .1
NEXT Integer_variable
```

Although it is not recommended programming practice, you can assign a value to a FOR...NEXT loop's *control variable* while in the loop. This affects the number of times a loop executes. For example, assigning a value that exceeds the ending value of a loop will cause the loop's execution to end as soon as VAX BASIC performs the termination test in the FOR statement. Assigning values to ending or step variables, however, has no effect at all on the loop's execution.

11.2.2 WHILE...NEXT Loops

A WHILE...NEXT statement uses a conditional expression to control loop execution; the loop is executed as long as a given condition is true. A WHILE...NEXT loop is useful when you do not know how many loop iterations are required.

In the following example, the first statement tells the user to input data and then type DONE when he is finished. After the user enters the first piece of input, VAX BASIC executes the WHILE...NEXT loop. If the first input value is not "DONE", the loop executes and prompts the user for another input value. Once the user enters this input value, the WHILE...NEXT loop once again checks to see if this value corresponds to "DONE". The loop will continue executing until the user types "DONE" in response to the prompt.

Example

```
INPUT 'Type "DONE" when finished'; Answer
WHILE (Answer <> "DONE")
   .
   .
   .
      INPUT "More data"; Answer
NEXT
```

Note that the NEXT statement in the WHILE...NEXT and UNTIL...NEXT loops does not increment a control variable; your program must change a variable in the conditional expression or the loop will execute indefinitely.

The evaluation of the conditional expression determines whether the loop executes. The test is performed (that is, the conditional expression is evaluated) before the first iteration; if the value is false (0), the loop does not execute.

It can be useful to intentionally create an infinite loop by coding a WHILE...NEXT loop whose conditional expression is always true. Of course, when doing this, you must still take care to provide a way out of the loop. You can do this with an EXIT statement or by trapping a run-time error. See Chapter 17 for more information about trapping run-time errors.

11.2.3 UNTIL...NEXT Loops

The UNTIL...NEXT loop behaves exactly like a WHILE...NEXT loop, except that the logical sense of the conditional expression is reversed; that is, the UNTIL...NEXT loop executes until a given condition is true.

An UNTIL...NEXT loop executes repeatedly for as long as the conditional expression is false. Note that in UNTIL...NEXT and WHILE...NEXT loops, the NEXT statement does not increment a control variable. You must explicitly change a variable in the conditional expression or the loop will execute indefinitely.

It is possible to code the example in Section 11.2.2 as an UNTIL...NEXT loop as shown in the following example. These loops are equivalent except for the logical sense of the termination test (WHILE *Answer* <> "DONE" as opposed to UNTIL *Answer* = "DONE").

Example

```
INPUT 'Type "DONE" when finished.'; Answer
UNTIL (Answer = "DONE")
   .
   .
   .
      INPUT "More data"; Answer
NEXT
```

UNTIL and FOR loops differ because VAX BASIC exits UNTIL loops as soon as the test for the terminating condition is met. This test occurs after VAX BASIC executes the NEXT statement and before it executes the UNTIL statement. For example, the following loop executes 10 times. When VAX BASIC exits the FOR loop, *J%* equals 10.

Example

```
FOR J% = 1% to 10%
    A = A + 1
    PRINT A
NEXT J%
```

The following UNTIL loop executes only nine times. After the ninth iteration, the conditional expression is true; control then passes out of the loop.

Example

```
J% = 1%
UNTIL J% = 10%
      PRINT J%
      J% = J% + 1%
NEXT
```

11.2.4 Nesting Loops

When a loop block is entirely contained in another loop block, it is called a *nested* loop.

The following example declares a two-dimensional array and uses nested FOR...NEXT loops to fill the array elements with sales information. The inner loop executes 16 times for each iteration of the outer loop. This example assigns a value to each of the 256 elements of the array.

Example

```
DECLARE
   INTEGER
      Column_number,
      Row_number
   REAL
      Sales_info,
      Two_dim_array (15%, 15%)
FOR Row_number = 0% TO 15%
    FOR Column_number = 0% to 15%
        INPUT "Please enter the sales information";Sales_info
        Two_dim_array (Row_number, Column_number) = Sales_info
    NEXT Column_number
NEXT Row_number
```

Note that in nested loops the inner loop is entirely contained in the outer loop: nested loops cannot overlap.

11.3 Unconditional Branching (the GOTO Statement)

The GOTO statement specifies which program line the VAX BASIC compiler is to execute next, regardless of that line's position in the program. If the statement at the target line number or label is nonexecutable (such as a REM statement), VAX BASIC transfers control to the next executable statement following the target line number.

You can use a GOTO statement to exit from a loop; however, it is better programming practice to use the EXIT statement.

11.4 Conditional Branching

Conditional branching is the transfer of program control only when specified conditions are met. There are three VAX BASIC statements that let you conditionally transfer control to a target statement in your program:

- The ON...GOTO...OTHERWISE statement
- The IF...THEN...ELSE statement
- The SELECT...CASE statement

11.4.1 The ON...GOTO...OTHERWISE Statement

In the ON...GOTO...OTHERWISE statement, VAX BASIC tests the value specified after the ON keyword. If the value is 1, VAX BASIC transfers control to the first target in the list; if the value is 2, control passes to the second target, and so on. If the value is less than 1, or greater than the number of targets in the list, VAX BASIC transfers control to the target specified in the OTHERWISE clause.

Example

```
Menu:
  PRINT "Would you like to change:"
  PRINT "1.  First name"
  PRINT "2.  Last name"

INPUT CHOICE%

ON CHOICE% GOTO First_name, Last_name OTHERWISE Other_choice

First_name:
   INPUT "First name"; firstname$
   GOTO Done

Last_name:
   INPUT "Last name"; lastname$
   GOTO Done

Other_choice:
    PRINT "Invalid choice"
    PRINT "Let's try again"
    GOTO Menu

Done:
    END
```

Note that if you do not supply an OTHERWISE clause and the control variable is less than 1 or greater than the number of targets, VAX BASIC signals "ON statement out of range (ERR = 58)".

11.4.2 The IF...THEN...ELSE Statement

The IF...THEN...ELSE statement evaluates a conditional expression and uses the result to determine which block of statements to execute next. If the conditional expression is true, VAX BASIC executes the statements in the THEN clause. If the conditional expression is false, VAX BASIC executes the statements in the ELSE clause, if one is present. If the conditional expression is false and there is no ELSE clause, VAX BASIC executes the statement immediately following the END IF statement.

In the following example, VAX BASIC evaluates the conditional expression *number* < 0. If the input value of *number* is less than zero, the conditional expression is true. VAX BASIC then executes the four statements in the THEN clause and skips the statement in the ELSE clause. VAX BASIC transfers control to the statement following the END IF. If the value of *number* is greater than or equal to zero, the conditional expression is false. VAX BASIC then skips the statements in the THEN clause and executes the statement in the ELSE clause.

Example

```
INPUT "Input number"; number

IF (number < 0)
THEN
   number = number * (-1)
   PRINT "That square root is imaginary"
   PRINT "The square root of its absolute value is";
   PRINT SQR(number)
ELSE
   PRINT "The square root is"; SQR(number)
END IF
END
```

Output

```
Input number? -9
That square root is imaginary
The square root of its absolute value is 3
```

One of the most common programming errors is neglecting to terminate an IF...THEN...ELSE statement. After an IF block is executed, control is transferred to the statement immediately following the END IF. If there is no END IF, VAX BASIC transfers control to the next line number. When this happens, any code between the keyword ELSE and the next line number becomes part of the ELSE clause. If there are no line numbers, the VAX BASIC compiler ignores the remaining program code from the keyword ELSE to the end of the program. Therefore, it is very important that you always use END IF to terminate IF statements.

In the following example, the first IF...THEN...ELSE statement is terminated by END IF, and therefore works as expected. Because the second IF...THEN...ELSE statement is not terminated by END IF, the VAX BASIC compiler assumes that the last PRINT statement in the program is part of the second ELSE clause. When you run this program, the first IF...THEN...ELSE statement will always execute correctly. However, the final PRINT statement will execute only when the value of *On_off_val* is 1, because the compiler considers this PRINT statement to be part of the second ELSE clause.

Example

```
10  DECLARE INTEGER light_bulb
    DECLARE INTEGER circuit_switch
    DECLARE INTEGER CONSTANT Opened  = 0
    DECLARE INTEGER CONSTANT Closed =  1

    PRINT "Please enter zero or one, corresponding to the circuit"
    PRINT "switch being open or closed"
    INPUT On_off_val
    IF On_off_val = Opened
      THEN
        PRINT "The light bulb is off."
      ELSE
        PRINT "The light bulb is on."
    END IF
    IF On_off_val = Closed
      THEN
        PRINT "The light bulb is on."
      ELSE
        PRINT "The light bulb is off."
        PRINT "That's all for now."
20  END
```

Output 1

```
Please enter zero or one, corresponding to the circuit
switch being open or closed
? 0
The light bulb is off.
The light bulb is off.
That's all for now.
```

Output 2

```
Please enter zero or one, corresponding to the circuit
Switch being open or closed
? 1
The light bulb is on.
The light bulb is on.
```

Note that a statement in a THEN or ELSE clause can be followed by a modifier. In this case, the modifying IF applies only to the statement that immediately precedes it.

Example

```
IF A = B
THEN
   PRINT A IF A = 3
ELSE
   PRINT B IF B > 0
END IF
```

11.4.3 The SELECT...CASE Statement

The SELECT...CASE statement lets you specify an expression (the SELECT expression), any number of possible values (cases) for the SELECT expression, and a list of statements (a CASE block) for each case. The SELECT expression can be a numeric or string value. CASE values can be single or multiple values, one or more ranges of values, or relationships. When a match is found between the SELECT expression and a CASE value, the statements in the following CASE block are executed. Control is then transferred to the statement following the END SELECT statement.

In the following example, the CASE values appear to overlap; that is, the CASE value that tests for values greater than or equal to 0.5 also includes the values greater than or equal to 1.0. However, VAX BASIC executes the statements associated with the *first* matching CASE statement and then transfers control to the statement following END SELECT. In this program, each range of values is tested *before* it overlaps in the next range. Because the compiler executes the first matching CASE statement, the overlapping values do not matter.

Example

```
DECLARE REAL Stock_change

INPUT "Please enter stock price change";Stock_change
SELECT Stock_change
CASE <= 0.5
     PRINT "Don't sell yet."
CASE <= 1.0
     PRINT "Sell today."
CASE ELSE
     PRINT "Sell NOW!"
END SELECT
END
```

Output

```
Please enter stock price change? 2.1
Sell NOW!
```

If no match is found for any of the specified cases and there is no CASE ELSE block, VAX BASIC transfers control to the statement following END SELECT without executing any of the statements in the SELECT block.

SELECT...CASE is powerful because it lets you use run-time expressions for both SELECT expressions and CASE values. The following example uses VAX BASIC built-in string functions to examine command input.

Example

```
! This program is a skeleton command processor.
! It recognizes three VAX BASIC environment commands:
!
!       SAVE
!       SCRATCH
!       OLD

DECLARE INTEGER CONSTANT True  = -1
DECLARE INTEGER CONSTANT False =  0

DECLARE STRING CONSTANT Null_input = ""   !This is the null string.

DECLARE STRING Command

! Main program logic starts here.

Command_loop:

WHILE True              ! This loop executes until the user types only a
                        ! carriage return in response to the prompt.

    PRINT
    PRINT "Please enter a command (uppercase only)."
    PRINT "Type a carriage return when finished."
    INPUT Command
    PRINT

    SELECT Command

    CASE Null_input                            ! If user types RETURN,
                                               ! exit from the loop
      GOTO Done                                ! and end the program.

    ! The next three cases use the SEG$ and LEN string functions.
    ! LEN returns the length of the typed string, and SEG$ searches
    ! the string literals ("SAVE", "SCRATCH", and "OLD") for a
    ! match up to that length.  Note that if the user types an "S",
    ! it is interpreted as a SAVE command only because SAVE is the
    ! first case tested.

    CASE SEG$ ( "SAVE", 1%, LEN (Command) )
      PRINT "That was a SAVE command."

    CASE SEG$ ( "SCRATCH", 1%, LEN (Command) )
      PRINT "That was a SCRATCH command."

    CASE SEG$( "OLD", 1%, LEN (Command) )
      PRINT "That was an OLD command."

    CASE ELSE
      PRINT "Invalid command, please try again."

    END SELECT
  NEXT

 Done:
      END
```

11.5 The EXIT and ITERATE Statements

This section describes the EXIT and ITERATE statements and shows their use with nested control structures.

The ITERATE and EXIT statements let you explicitly control loop execution. These statements can be used to transfer control to the top or bottom of a control structure.

You can use EXIT to transfer control out of any of these structures:

- FOR...NEXT loops
- WHILE...NEXT loops
- UNTIL...NEXT loops
- IF...THEN...ELSE blocks
- SELECT...CASE blocks
- SUB, FUNCTION, and PICTURE subprograms
- DEF functions, and programs

In the case of control structures, EXIT passes control to the first statement following the end of the control structure.

You can use ITERATE to explicitly reexecute a FOR...NEXT, WHILE...NEXT, or UNTIL...NEXT loop. EXIT and ITERATE statements can appear only within the code blocks you wish to leave or reexecute.

Executing the ITERATE statement is equivalent to transferring control to the loop's NEXT statement. The termination test is still performed when the NEXT statement transfers control to the top of the loop. In addition, transferring control to the NEXT statement means that a FOR loop's control variable is incremented.

Supplying a label for every loop lets you state explicitly which loop to leave or reexecute. If you do not supply a label for the ITERATE statement, VAX BASIC reexecutes the innermost active loop. For example, if an ITERATE statement (that does not specify a label) is executed in the innermost of three nested loops, only the innermost loop is reexecuted.

In contrast, labeling each loop and supplying a label argument to the ITERATE statement lets you reexecute any of the loops. A label name also helps document your code. Because you must use a label with EXIT and it is sometimes necessary to use a label with ITERATE, you should always label the structures you want to control with these statements.

The following example shows the use of both the EXIT and ITERATE statements. This program explicitly exits the loop if you type a carriage return in response to the prompt. If you type a string, the program prints the length of the string and explicitly reexecutes the loop.

Example

```
DECLARE STRING User_string

Read_loop:
WHILE 1% = 1%
      LINPUT "Please type a string"; User_string

      IF User_string == ""
         THEN
            EXIT Read_loop
         ELSE
            PRINT "Length is ";LEN(User_string)
            ITERATE Read_loop
       END IF
NEXT
END
```

11.6 Executing Local Subroutines

In VAX BASIC, a subroutine is a block of code accessed by a GOSUB or ON GOSUB statement. It must be in the same program unit as the statement that calls it. The RETURN statement in the subroutine returns control to the statement immediately following the GOSUB.

The first line of a subroutine can be any valid VAX BASIC statement, including a REM statement. You do not have to transfer control to the first line of the subroutine. Instead, you can include several entry points into the same subroutine. You can also reference subroutines by using a GOSUB or ON GOSUB statement to another subroutine.

Variables and data in a subroutine are global to the program unit in which the subroutine resides.

11.6.1 The GOSUB and RETURN Statements

The GOSUB statement unconditionally transfers control to a line in a subroutine. The last statement in a subroutine is a RETURN statement, which returns control to the first statement after the calling GOSUB. A subroutine can contain more than one RETURN statement so you can return control conditionally, depending on a specified condition.

The following example first assigns a value of 5 to the variable *A*, then transfers control to the subroutine labeled *Times_two*. This subroutine replaces the value of *A* with *A* multiplied by 2. The subroutine's RETURN statement transfers control to the first PRINT statement, which displays the changed value. The program calls the subroutine two more times, with different values for *A*. Each time, the RETURN transfers control to the statement immediately following the corresponding GOSUB.

Example

```
A = 5
GOSUB Times_two
PRINT A

A = 15
GOSUB Times_two
PRINT A

A = 25
GOSUB Times_two
PRINT A

GOTO Done

Times_two:
    !This is the subroutine entry point
    A = A * 2
    RETURN

Done:
    END
```

Output

```
10
30
50
```

Note that VAX BASIC signals "RETURN without GOSUB" if it encounters a RETURN statement without first having encountered a GOSUB or ON GOSUB statement.

11.6.2 The ON...GOSUB...OTHERWISE Statement

The ON...GOSUB...OTHERWISE statement transfers control to one of several target subroutines depending on the value of a numeric expression. A RETURN statement returns control to the first statement after the calling ON GOSUB. A subroutine can contain more than one RETURN statement so that you can return control conditionally, depending on a specified condition.

VAX BASIC tests the value of the integer expression. If the value is 1, control transfers to the first line number or label in the list; if the value is 2, control passes to the second line number or label, and so on. If the control variable's value is less than 1 or greater than the number of targets in the list, VAX BASIC transfers control to the line number or label specified in the OTHERWISE clause. If you do not supply an OTHERWISE clause and the control variable's value is less than 1 or greater than the number of targets, VAX BASIC signals "ON statement out of range (ERR=58)".

Example

```
INPUT "Please enter first integer value"; First_value%
INPUT "Please enter second integer value"; Second_value%

Choice:
    PRINT "Do you want to perform:"
    PRINT "1.  Multiplication"
    PRINT "2.  Division"
    PRINT "3.  Exponentiation"

INPUT Selection%

ON Selection% GOSUB Mult, Div, Expon OTHERWISE Wrong
GOTO Done

Mult:
    Result% = First_value% * Second_value%
    PRINT Result%
    RETURN

Div:
    Result% = First_value / Second_value%
    PRINT Result%
    RETURN

Expon:
    Result% = First_value% ** Second_value%
    PRINT Result%
    RETURN

Wrong:
    PRINT "Invalid selection"
    RETURN

Done:
    END
```

11.7 Suspending and Halting Program Execution

There are two VAX BASIC statements that you can use to suspend program execution:

- SLEEP
- WAIT

These statements cause VAX BASIC either to suspend program execution for a specified time or to wait a certain period of time for user input.

After execution of the last statement, a VAX BASIC program automatically halts and closes all files. However, you can explicitly halt program execution by using one of the following statements:

- STOP
- END

The STOP statement does not close files. It can appear anywhere in a program. The END statement closes files and must be the last statement in a main program. For more information on the STOP and END statements, see Section 11.7.3 and Section 11.7.4.

11.7.1 The SLEEP Statement

The SLEEP statement suspends program execution for a specified number of seconds. The following program waits two minutes (120 seconds) after receiving the input string, and then prints it.

Example

```
INPUT "Type a string of characters"; C$
SLEEP 120%
PRINT C$
END
```

The SLEEP statement is useful if you have a program that depends on another program for data. Instead of constantly checking for a condition, the SLEEP statement lets you check the condition at specified intervals.

11.7.2 The WAIT Statement

You use the WAIT statement only with terminal input statements such as INPUT, INPUT LINE, and LINPUT. For example, the following program prompts for input, then waits 30 seconds for your response. If the program does not receive input in the specified time, VAX BASIC signals "Keyboard wait exhausted (ERR=15)" and exits the program.

Example

```
WAIT 30%
INPUT "You have 30 seconds to type your password"; PSW$
END
```

The WAIT statement affects all subsequent INPUT, INPUT LINE, LINPUT, MAT INPUT, and MAT LINPUT statements. To disable a previously specified WAIT statement, use WAIT 0%.

In the following example, the first WAIT statement causes the first INPUT statement to wait 30 seconds for a response. The WAIT 0% statement disables this 30-second requirement for all subsequent INPUT statements.

Example

```
WAIT 30%
INPUT "You have 30 seconds to type your  password"; PSW$
WAIT 0%
INPUT "What directory do you want to go to"; DIR$
```

11.7.3 The STOP Statement

The STOP statement is a debugging tool that lets you check the flow of program logic. STOP suspends program execution but does not close files.

When VAX BASIC executes a STOP statement, it signals "STOP at line <line-num>". If the program executes in the BASIC environment, VAX BASIC then prompts with the DCL command level prompt. In response, you can type:

- Immediate mode statements (to examine or change program values)
- The CONTINUE statement (to continue program execution)

You use the STOP statement when debugging in immediate mode in the BASIC environment. For more information on immediate mode statements, see Chapter 3 in this manual.

If you compile, link, and execute a program containing a STOP statement at DCL command level, VAX BASIC displays a number sign (#) prompt when the STOP statement is encountered. At this point, you can type:

- CONTINUE (to continue program execution)
- EXIT (to return to DCL command level)

11.7.4 The END Statement

The END statement marks the end of a main program. When VAX BASIC executes an END statement it closes all files and halts program execution.

The END statement is optional in VAX BASIC programs. However, you should include it for good programming practice. The END statement must be the last statement in the main program.

If you run your program in the BASIC environment, the END statement returns you to VAX BASIC command level. If you execute the program outside the BASIC environment, the END statement returns you to DCL command level.

Chapter 12

Functions

A *function* is a single statement or group of statements that perform operations on operands and return the result to your program. VAX BASIC has built-in functions that perform numeric and string operations, conversions, and date and time operations. This chapter describes only a selected group of built-in functions. For a complete description of all VAX BASIC built-in functions, see the *VAX BASIC Reference Manual.*

This chapter also describes user-defined functions. VAX BASIC lets you define your own functions in two ways:

- With the DEF statement
- As separately compiled subprograms (external functions)

DEF function definitions are local to a program module, while external functions can be accessed by any program module. You create local functions with the DEF statement and optionally declare them with the DECLARE statement. You create external functions with the FUNCTION statement and declare them with the EXTERNAL statement. For more information on creating external functions with the FUNCTION statement, see Chapter 14.

Once you have created and declared a function, you can invoke it just as you would a built-in function.

12.1 Built-In Functions

The functions described in this section let you perform sophisticated manipulations of string and numeric data. VAX BASIC also provides algebraic, exponential, trigonometric, and randomizing mathematical functions.

12.1.1 Numeric Functions

Numeric functions generally return a result of the same data type as the function's parameter. For example, if you pass a DOUBLE argument to any of the trigonometric functions, they return a DOUBLE result.

If the format of a VAX BASIC function specifies an argument of a particular data type, VAX BASIC converts the actual argument supplied to the specified data type. For instance, if you supply an integer argument to a function that expects a floating-point number, VAX BASIC converts the argument to floating-point. Floating-point arguments that are passed to integer functions are truncated, not rounded.

The following are some examples of VAX BASIC built-in numeric functions.

12.1.1.1 The ABS Function

The ABS function returns a floating-point number that equals the absolute value of a specified numeric expression. The following is an example of the ABS function.

Example

```
READ A,B
DATA 10,-35.3
NEW_A = ABS(A)
PRINT NEW_A; ABS(B)
END
```

Output

```
 10  35.3
```

ABS always returns a number of the default floating-point data type.

12.1.1.2 The INT and FIX Functions

The INT function returns the floating-point value of the largest integer less than or equal to a specified expression. INT always returns a number of the default floating-point type.

The FIX function truncates the value of a floating-point number at the decimal point. FIX always returns a number of the default floating-point type.

The following example points out the differences between the INT and FIX functions. Note that the value returned by FIX(–45.3) differs from the value returned by INT(–45.3).

Example

```
PRINT INT(23.553); FIX(23.553)
PRINT INT(3.1); FIX(3.1)
PRINT INT(-45.3); FIX(-45.3)
PRINT INT(-11); FIX(-11)
END
```

Output

```
 23  23
 3  3
-46 -45
-11 -11
```

12.1.1.3 The SIN, COS, and TAN Functions

The SIN, COS, and TAN functions return the sine, cosine, and tangents of an angle in radians or degrees, depending on which angle clause you choose with the OPTION statement. If you supply a floating-point argument to the SIN, COS, and TAN functions, they return a number of the same floating-point type. If you supply an integer argument, they convert the argument to the default floating-point data type and return a floating-point number of that type.

The following program accepts an angle in degrees, converts the angle to radians, and prints the angle's sine, cosine, and tangent.

Example

```
!CONVERT ANGLE (X) TO RADIANS, AND
!FIND SIN, COS AND TAN
PRINT "DEGREES", "RADIANS", "SINE", "COSINE","TANGENT"
FOR I% = 0% TO 5%
    READ X
    LET Y = X * 2 * PI / 360
    PRINT
    PRINT X ,Y ,SIN(Y) ,COS(Y) ,TAN(Y)
NEXT I%

DATA 0,10,20,30,360,45
END
```

Output

```
DEGREES       RADIANS       SINE          COSINE        TANGENT

 0             0             0             1             0

 10            .174533       .173648       .984808       .176327

 20            .349066       .34202        .939693       .36397

 30            .523599       .5            .866025       .57735
```

360	6.28319	.174846E-06	1	.174846E-06
45	.785398	.707107	.707107	1

NOTE

As an angle approaches 90 degrees (PI/2 radians), 270 degrees (3*PI/2 radians), 450 degrees (5*PI/2 radians), and so on, the tangent of that angle approaches infinity. If your program tries to find the tangent of such an angle, VAX BASIC signals "Division by 0" (ERR=61).

12.1.1.4 The LOG10 Function

A logarithm is the exponent of some number (called a base). Common logarithms use the base 10. The common logarithm of a number *n*, for example, is the power to which 10 must be raised to equal *n*. For example, the common logarithm of 100 is 2, because 10 raised to the power 2 equals 100.

The LOG10 function returns a number's common logarithm. The following example calculates the common logarithms of all multiples of 10 from 10 to 100, inclusive.

Example

```
FOR I% = 10% TO 100% STEP 10%
    PRINT LOG10(I%)
NEXT I%
END
```

Output

```
 1
 1.30103
 1.47712
 1.60206
 1.69897
 1.77815
 1.8451
 1.90309
 1.95424
 2
```

If you supply a floating-point argument to LOG10, the function returns a floating-point number of the same data type. If you supply an integer argument, LOG10 converts it to the default floating-point data type and returns a value of that type.

12.1.1.5 The EXP Function

The EXP function returns the value of *e* raised to a specified power. The following example prints the value of *e* and *e* raised to the second power.

Example

```
READ A,B
DATA 1,2
PRINT 'e RAISED TO THE POWER'; A; " EQUALS"; EXP(A)
PRINT 'e RAISED TO THE POWER'; B; " EQUALS"; EXP(B)
END
```

Output

```
e RAISED TO THE POWER 1 EQUALS 2.71828
e RAISED TO THE POWER 2 EQUALS 7.38906
```

If you supply a floating-point argument to EXP, the function returns a floating-point number of the same data type. If you supply an integer argument, EXP converts it to the default floating-point data type and returns a value of that type.

12.1.1.6 The RND Function

The RND function returns a number greater than or equal to zero and less than 1. The RND function always returns a floating-point number of the default floating-point data type. The RND function generates seemingly unrelated numbers. However, given the same starting conditions, a computer always gives the same results. Each time you execute a program with the RND function, you receive the same results.

Example

```
PRINT RND,RND,RND,RND
END
```

Output 1

```
 .76308       .179978      .902878      .88984
```

Output 2

```
 .76308       .179978      .902878      .88984
```

With the RANDOMIZE statement, you can change the RND function's starting condition and generate truly random numbers. To do this, place a RANDOMIZE statement before the line invoking the RND function. Note that the RANDOMIZE statement should be used only once in a program. With the RANDOMIZE statement, each invocation of RND returns a new and unpredictable number.

Example

```
RANDOMIZE
PRINT RND,RND,RND,RND
END
```

Output 1

```
 .403732       .34971       .15302       .92462
```

Output 2

```
 .404165       .272398      .261667      .10209
```

The RND function can generate a series of random numbers over any open range. To produce random numbers in the open range *A* to *B*, use the following formula:

```
(B-A)*RND + A
```

The following program produces 10 numbers in the open range 4 to 6.

Example

```
FOR I% = 1% TO 10%
    PRINT (6%-4%) * RND + 4
NEXT I%
END
```

Output

```
 5.52616
 4.35996
 5.80576
 5.77968
 4.77402
 4.95189
 5.76439
 4.37156
 5.2776
 4.53843
```

12.1.2 Data Conversion Functions

VAX BASIC provides built-in functions that can:

- Convert a 1-character string to the character's ASCII value and vice versa
- Translate strings from one data format to another, for example, EBCDIC to ASCII

The following sections describe some of these functions.

12.1.2.1 The ASCII Function

The ASCII function returns the numeric ASCII value of a string's first character. The ASCII function returns an integer value between 0 and 255, inclusive. For instance, in the following example, the PRINT statement prints the integer value 66 because this is the ASCII value equivalent of an uppercase B, the first character in the string.

Example

```
test_string$ = "BAT"
PRINT ASCII(test_string$)
END
```

Output

```
 66
```

Note that the ASCII value of a null string is zero.

12.1.2.2 The CHR$ Function

The CHR$ function returns the character whose ASCII value you supply. If the ASCII integer expression that you supply is less than zero or greater than 255, VAX BASIC treats it as a modulo 256 value. In other words, VAX BASIC treats the integer expression as the remainder of the actual supplied integer divided by 256. Therefore, CHR$(325) is equivalent to CHR$(69) and CHR$(–1) is equivalent to CHR$(255).

The following program outputs the character whose ASCII value corresponds to the input value modulo 256.

Example

```
PRINT "THIS PROGRAM FINDS THE CHARACTER WHOSE"
PRINT "VALUE (MODULO 256) YOU TYPE"
INPUT value%
PRINT CHR$(value%)
END
```

Output 1

```
THIS PROGRAM FINDS THE CHARACTER WHOSE
VALUE (MODULO 256) YOU TYPE
 ? 69
E
```

Output 2

```
THIS PROGRAM FINDS THE CHARACTER WHOSE
VALUE (MODULO 256) YOU TYPE
 ? 1093
E
```

12.1.3 String Numeric Functions

Numeric strings are numbers represented by ASCII characters. A numeric string consists of an optional sign, a string of digits, and an optional decimal point. You can use E notation in a numeric string for floating-point constants.

The following sections describe some of the VAX BASIC numeric string functions.

12.1.3.1 The FORMAT$ Function

The FORMAT$ function converts a numeric value to a string. The output string is formatted according to a string you provide. The expression you give this function can be any string or numeric expression. The format string must contain at least one PRINT USING format field. The formatting rules are the same as those for printing numbers with PRINT USING. See Chapter 16 in this manual for more information on the PRINT USING statement and formatting rules.

Example

```
A = 5
B$ = "##.##"
Z$ = FORMAT$(A, B$)
PRINT Z$
END
```

Output

```
 5.00
```

12.1.3.2 The NUM$ and NUM1$ Functions

The NUM$ function evaluates a numeric expression and returns a string of characters formatted as the PRINT statement would format it. The returned numeric string is preceded by one space for positive numbers and by a minus sign for negative numbers. The numeric string is always followed by a space, as shown in the following example.

Example

```
PRINT NUM$(7465097802134)
PRINT NUM$(-50)
END
```

Output

```
 .74651E+13
-50
```

The NUM1$ function translates a number into a string of numeric characters. NUM1$ does not return leading or trailing spaces or E format. The following example illustrates the use of the NUM1$ function.

Example

```
PRINT NUM1$(PI)
PRINT NUM1$(97.5 * 30456.23 + 30385.1)
PRINT NUM1$(1E-38)
END
```

Output

```
3.14159
2999870
.00000000000000000000000000000000000001
```

NUM1$ returns up to 6 digits of accuracy for single-precision real numbers, up to 16 digits of accuracy for double-precision numbers, and up to 10 digits of accuracy for LONG integers. NUM1$ returns up to 15 digits of accuracy for GFLOAT numbers and up to 33 digits of accuracy for HFLOAT numbers.

The following example shows the difference between NUM$ and NUM1$.

Example

```
A$ = NUM$(1000000)
B$ = NUM1$(1000000)
PRINT LEN(A$); "/"; A$; "/"
PRINT LEN(B$); "/"; B$; "/"
END
```

Output

```
 8 / .1E+07 /
 7 /1000000/
```

Note that *A$* has a leading and trailing space.

12.1.3.3 The VAL% and VAL Functions

The VAL% function returns the integer value of a numeric string. This numeric string expression must be the string representation of an integer. It can contain the ASCII characters 0 through 9, a plus sign (+), and a minus sign (−).

The VAL function returns the floating-point value of a numeric string. The numeric string expression must be the string representation of some number. It can contain the ASCII characters 0 through 9, a plus sign (+), a minus sign (−), and an uppercase E.

VAL returns a number of the default floating-point data type. VAX BASIC signals "Illegal number" (ERR=52) if the argument is outside the range of the default floating-point data type.

The following is an example of VAL and VAL%.

Example

```
A = VAL("922")
B$ = "100"
C% = VAL%(B$)
PRINT A
PRINT C%
END
```

Output

```
 922
 100
```

12.1.4 String Arithmetic Functions

String arithmetic functions process numeric strings as arithmetic operands. This lets you add (SUM$), subtract (DIF$), multiply (PROD$), and divide (QUO$) numeric strings, and express them at a specified level of precision (PLACE$).

String arithmetic offers greater precision than floating-point arithmetic or longword integers, and it eliminates the need for scaling. However, string arithmetic executes much more slowly than the corresponding integer or floating-point operations.

The operands for the functions can be numeric strings representing any integer or floating-point value (E notation is not valid). Table 12–1 shows the string arithmetic functions and their formats, and gives brief descriptions of what they do.

Table 12–1: String Arithmetic Functions

Function	Format	Description
SUM$	SUM$(A$,B$)	B$ is added to A$.
DIF$	DIF$(A$,B$)	B$ is subtracted from A$.
PROD$	PROD$(A$,B$,P%)	A$ is multiplied by B$. The product is expressed with precision P%.
QUO$	QUO$(A$,B$,P%)	A$ is divided by B$. The quotient is expressed with precision P%.
PLACE$	PLACE$(A$,P%)	A$ is expressed with precision P%.

String arithmetic computations permit 56 significant digits. The functions QUO$, PLACE$, and PROD$, however, permit up to 60 significant digits. Table 12–2 shows how VAX BASIC determines the precision permitted by each function and if that precision is implicit or explicit.

Table 12–2: Precision of String Arithmetic Functions

Function	How Determined	How Stated
SUM$	Precision of argument	Implicitly
DIF$	Precision of argument	Implicitly
PROD$	Value of argument	Explicitly
QUO$	Value of argument	Explicitly
PLACE$	Value of argument	Explicitly

12.1.4.1 The SUM$ and DIF$ Functions

SUM$ and DIF$ take the precision of the more precise argument in the function unless padded zeros generate that precision. SUM$ and DIF$ omit trailing zeros to the right of the decimal point.

The size and precision of results returned by the SUM$ and DIF$ functions depend on the size and precision of the arguments involved:

- The sum or difference of two integers takes the precision of the larger integer.
- The sum or difference of two decimal fractions takes the precision of the more precise fraction.

- The sum or difference of two real numbers takes precision as follows:
  - The sum or difference of the integer parts takes the precision of the larger part.
  - The sum or difference of the decimal fraction parts takes the precision of the more precise part.
- VAX BASIC truncates trailing zeros.

12.1.4.2 The QUO$, PLACE$, and PROD$ Functions

In the QUO$, PLACE$, and PROD$ functions, the value of the integer expression argument explicitly determines numeric precision. That is, the integer expression parameter determines the point at which the number is rounded or truncated.

If the integer expression is between –5000 and 5000, rounding occurs according to the following rules:

- For positive integer expressions, rounding occurs to the right of the decimal place. For example, if the integer expression is 1, rounding occurs one digit to the right of the decimal place (the number is rounded to the nearest tenth). If 2, rounding occurs two digits to the right of the decimal place (the number is rounded to the nearest hundredth), and so on.
- For zero, VAX BASIC rounds to the nearest unit.
- For negative integer expressions, rounding occurs to the left of the decimal place. For example, if the integer expression is –1, rounding occurs one place to the left of the decimal point. In this case, VAX BASIC moves the decimal point one place to the left, then rounds to units. If the integer expression is –2, rounding occurs two places to the left of the decimal point; VAX BASIC moves the decimal point two places to the left, then rounds to units.

Note that when rounding numeric strings, VAX BASIC returns only part of the number.

If the integer expression is between 5001 and 15000, the following rules apply:

- If the integer expression is 10000, VAX BASIC truncates the number at the decimal point.

- If the integer expression is greater than 10000 (10000 plus *n*) VAX BASIC truncates the numeric string *n* places to the right of the decimal point. For example, if the integer expression is 10001 (10000 plus 1), VAX BASIC truncates the number starting one place to the right of the decimal point. If 10002 (10000 plus 2), VAX BASIC truncates the number starting two places to the right of the decimal point, and so on.
- If the integer expression is less than 10000 (10000 minus *n*) VAX BASIC truncates the numeric string *n* places to the left of the decimal point. For example, if the integer expression is 9999 (10000 minus 1), VAX BASIC truncates the number starting one place to the left of the decimal point. If 9998 (10000 minus 2), VAX BASIC truncates starting two places to the left of the decimal point, and so on.

The PLACE$ function returns a numeric string, truncated or rounded according to an integer argument you supply.

The following example displays the use of the PLACE$ function with several different integer expression arguments.

Example

```
number$ = "123456.654321"
FOR I% = -5% TO 5%
    PRINT PLACE$(number$, I%)
NEXT I%
PRINT
FOR I% = 9995 TO 10005
    PRINT PLACE$(number$, I%)
NEXT I%
```

Output

```
1
12
123
1235
12346
123457
123456.7
123456.65
123456.654
123456.6543
123456.65432
```

```
1
12
123
1234
12345
123456
123456.6
123456.65
123456.654
123456.6543
123456.65432
```

The PROD$ function returns the product of two numeric strings. The returned string's precision depends on the value you specify for the integer precision expression.

Example

```
A$ = "-4.333"
B$ = "7.23326"
s_product$ = PROD$(A$, B$, 10005%)
PRINT s_product$
END
```

Output

```
-31.34171
```

12.1.5 Date and Time Functions

VAX BASIC supplies functions to return the date and time in numeric or string format. The following sections discuss these functions.

Note that you can also use certain system services and Run-Time Library routines for more sophisticated date and time functions. See the *VMS System Services Reference Manual* and the *VMS Run-Time Library Routines Volume* for more information.

12.1.5.1 The DATE$ Function

The DATE$ function returns a string containing a day, month, and year in the form *dd-Mmm-yy*. The date integer argument to the DATE$ function can have up to six digits in the form *yyyddd*, where *yyy* specifies the number of years since 1970 and *ddd* specifies the day of that year. If the numeric expression is zero, DATE$ returns the current date.

Example

```
PRINT DATE$(0)
PRINT DATE$(126)
PRINT DATE$(6168)
END
```

Output

```
15-Jun-85
06-May-70
16-Jun-76
```

If you supply an invalid date (for example, day 370 of 1973), the results are undefined.

12.1.5.2 The TIME$ Function

The TIME$ function returns a string displaying the time of day in the form *hh:mm* AM or *hh:mm* PM. TIME$ returns the time of day at a specified number of minutes before midnight. If you specify zero in the numeric expression, TIME$ returns the current time of day.

Example

```
PRINT TIME$(0)
PRINT TIME$(1)
PRINT TIME$(1440)
PRINT TIME$(721)
END
```

Output

```
03:53 PM
11:59 PM
12:00 AM
11:59 AM
```

12.1.5.3 The TIME Function

The TIME function requests time and usage information from the operating system and returns it to your program. The information returned by the TIME function depends on the value of the argument passed to it. The values and the information they return are as follows:

0	Returns the number of seconds elapsed since midnight
1	Returns the current job's CPU time in tenths of a second
2	Returns the current job's connect time in seconds

3 Returns zero

4 Returns zero

All other arguments to TIME are undefined and cause VAX BASIC to signal "Not implemented" (ERR=250).

12.1.6 Terminal Control Functions

VAX BASIC provides several terminal control functions. These functions let you:

- Enable and disable CTRL/C trapping
- Enable and disable terminal echoing
- Read a single keystroke from a terminal

12.1.6.1 The CTRLC and RCTRLC Functions

The CTRLC function enables CTRL/C trapping, and the RCTRLC function disables CTRL/C trapping. When CTRL/C trapping is enabled, control is transferred to the program's error handler when a CTRL/C is detected at the controlling terminal.

CTRL/C trapping is asynchronous. The trap can occur in the middle of an executing statement, and a statement so interrupted leaves variables in an undefined state. For example, the statement A$ = "ABC", if interrupted by CTRL/C, could leave the variable *A$* partially set to "ABC" and partially left with its old contents.

For example, if you type a CTRL/C to the following program when CTRL/C trapping is enabled, an "ABORT" message prints to the file open on channel #1. This lets you know that the program did not end correctly.

Example

```
WHEN ERROR USE error_handler
      Y% = CTRLC
    .
    .
    .
END WHEN
HANDLER error_handler
      IF ERR = 28 THEN PRINT #1%, "Abort"
    .
    .
    .
END HANDLER
```

NOTE

When you trap a CTRL/C with an error handler, your program may be in an inconsistent state; therefore, you should handle the CTRL/C error and exit the program as quickly as possible.

12.1.6.2 The ECHO and NOECHO Functions

The NOECHO function disables echoing on a specified channel. Echoing is the process by which characters typed at the terminal keyboard appear on the screen.

If you specify channel #0 (your terminal) as the argument, the characters typed on the keyboard are still accepted as input; however, they do not appear on the screen.

The ECHO function enables echoing on a specified channel and cancels the effect of the NOECHO function on that channel.

If you do not use these functions, ECHO is the default. This program shows a password routine in which the password does not echo.

Example

```
Y% = NOECHO(0%)
INPUT "PASSWORD"; pword$
IF pword$=="PLUGH" THEN PRINT "THAT IS CORRECT"
END IF
Y% = ECHO(0%)
END
```

Note that the Y% = ECHO(0%) statement is necessary to turn the echo back on. If this statement were not included, then all subsequent user inputs would not echo to the terminal screen.

12.1.6.3 The INKEY$ Function

The INKEY$ function reads a single keystroke from a terminal opened on a specified channel and returns the typed character.

If you specify a channel that is not open, VAX BASIC signals the error "I/O channel not open" (ERR=9). If a file or a device other than a terminal is open on the channel, VAX BASIC signals the error "Illegal operation" (ERR=141).

Once you have specified a channel, VAX BASIC allows you to specify an optional WAIT clause. A WAIT clause followed by no value tells VAX BASIC to wait indefinitely for input to become available. A WAIT clause followed by a value from 1 through 255 tells VAX BASIC to wait the specified number of seconds for input.

Example

```
DECLARE STRING
KEYSTROKE Inkey_Loop: WHILE 1%      KEYSTROKE = INKEY$(1%,WAIT)

      SELECT KEYSTROKE
          CASE '26'C
               PRINT "CTRL/Z to exit"
               EXIT Inkey_Loop
          CASE CR,LF,VT,FF,ESC
               PRINT "Line terminator"
          CASE "PF1" TO "PF4"
               PRINT "P key"
          CASE "E1" TO "E6"
               PRINT "VT200 Function key"
          CASE "KP0" TO "KP9"
               PRINT "Application keypad key"
          CASE < SP
               PRINT "Control character"
          CASE '127'C
               PRINT "<DEL>"
          CASE ELSE
               PRINT "Character is "; KEYSTROKE
      END SELECT
NEXT
```

12.2 User-Defined Functions

The DEF statement lets you create your own single-line or multiline functions.

In the traditional VAX BASIC usage, a function name consists of the following:

- The letters FN

- From 1 to 28 letters, digits, underscores, or periods
- An optional percent sign or dollar sign

Integer function names must end with a percent sign and string function names must end with a dollar sign. Therefore, the function name can have up to 31 characters. If the function name ends with neither a percent sign nor a dollar sign, the function returns a real number.

You can create user-defined functions using these function naming rules. However, DIGITAL recommends that you use explicit data typing when defining functions for new program development. Refer to Chapter 14 for an example of an explicitly declared function. Note that the function name must start with FN only if the function is not explicitly declared and a function reference lexically precedes the function definition.

DEF functions can be either single-line or multiline. Whether you use the single-line or multiline format for function definitions depends on the complexity of the function you create. In general, multiline DEF functions perform more complex functions than single-line DEF functions, and are suitable for recursive operations.

If you want to pass values to a function, the function definition requires a formal parameter list. These formal parameters are the variables used to calculate the value returned by the function. When you invoke a function, you supply an actual parameter list; the values in the actual parameter list are copied into the formal parameter at this time. DEF functions allow up to 255 formal parameters. You can specify variables, constants, or array elements as formal parameters, but you cannot specify an entire array as a parameter to a DEF function.

12.2.1 Single-Line DEF Functions

In a single-line DEF, the function name, the formal parameter list, and the defining expression all appear on the same line. The defining expression specifies the calculations that the function performs. You can pass up to 255 arguments to this function through the formal parameter list. These parameters are variables local to the function definition, and each formal parameter can be preceded by a data type keyword.

The following example creates a function named *fnratio*. This function has two formal parameters: *numer* and *denomin*, whose ratio is returned as a REAL value.

When the function is invoked, VAX BASIC does the following:

- Copies the values 5.6 and 7.8 into the formal parameters *numer* and *denomin*
- Evaluates the expression to the right of the equal sign
- Returns the value to the statement that invoked the function (the PRINT statement)

The PRINT statement then prints the returned value.

Example

```
DEF REAL fnratio (numer, denomin) = numer / denomin
PRINT fnratio(5.6, 7.8)
END
```

Output

```
 .717949
```

Note that the actual parameters you supply must agree in number and data type with those in the formal parameter list; you must supply numeric values for numeric variables, and string values for string variables.

The defining expression for a single-line function definition can contain any constant, variable, VAX BASIC built-in function, or any user-defined function except the function being defined. The following examples are valid function definitions.

Examples

```
DEF FN_A(X) = X^2 + 3 * X + 4
DEF FN_B(X) = FN_A(X) / 2 + FN_A(X)
DEF FN_C(X) = SQR(X+4) + 1
DEF CUBE(X) = X ^ 3
```

Note that the name of the last function defined does not begin with FN. This is valid as long as no reference to the function lexically precedes the function definition.

You can also define a function that has no formal parameters. For instance, the following function definition uses three VAX BASIC built-in functions to return an integer corresponding to the day of the month. DATE$(0) returns a date string in the form *dd-Mmm-yy*. The SEG$ function strips out of this value the characters starting at character position 1 up to and including the character at position 2 (the day number). The VAL% function converts this resulting numeric string to an integer. In this way, *fnday_number* returns the day of the month as an integer.

```
DEF INTEGER fnday_number = VAL% (SEG$(DATE$(0%), 1%, 2%))
```

12.2.2 Multiline DEF Functions

The DEF statement can also define multiline functions. Multiline DEF functions are useful for expressing complicated functions. Note that multiline DEF functions do not have the equal sign and defining expression on the first line. Instead, this expression appears in the function block, assigned to the function name.

NOTE

> If a multiline DEF function contains DATA statements, they are global to the program unit.

Multiline function definitions can contain any constant, variable, VAX BASIC built-in function, or user-defined function. In VAX BASIC, the function definition can contain a reference to the function you are defining. Therefore, a multiline DEF function can be recursive, or invoke itself. However, VAX BASIC does not detect infinitely recursive DEF functions during compilation. If your program invokes an infinitely recursive DEF function, VAX BASIC will eventually signal a fatal run-time error, typically the error, "Access violation".

You can use either the END DEF or EXIT DEF statements to exit from a user-defined function. The EXIT DEF statement is equivalent to an unconditional transfer to the END DEF statement.

The following example shows a multiline DEF function that uses both the EXIT and END DEF statements. The defining expression of the function is in the ELSE clause. This assigns a value to the function if *A* is less than 10. The second set of output shows what happens when *A* is greater than 10; VAX BASIC prints "OUT OF RANGE" and executes the EXIT DEF statement. The function returns zero because control is transferred to the END DEF statement before a value was assigned. In this way, this example tests the arguments before the function is evaluated.

Example

```
DEF fn_discount(A)
    IF A > 10
    THEN
       PRINT "OUT OF RANGE"
       EXIT DEF
    ELSE
       fn_discount = A^A
    END IF
END DEF
```

```
INPUT Z
PRINT fn_discount(Z)
END
```

Output 1

```
? 4
 256
```

Output 2

```
? 12
OUT OF RANGE
 0
```

If you do not explicitly declare the function with the DECLARE statement, the restrictions for naming a multiline DEF function are the same as those for the single-line DEF function. However, explicitly declaring a DEF function can make a program easier to read and understand. For instance, Example 1 concatenates two strings and Example 2 returns a number in a specified modulus.

Example 1

```
DECLARE STRING FUNCTION concat (STRING, STRING) !Declare the function
   .
   .
   .
DEF STRING concat (STRING Y, STRING Z)
concat = Y + Z  !Define the function
FNEND
   .
   .
   .
new_string$ = concat(A$, B$) !Invoke the function
   .
   .
   .
END
```

Example 2

```
DECLARE REAL FUNCTION mdlo (REAL, INTEGER)
DEF mdlo( REAL  argument, INTEGER modulus )
  !Check for argument equal to zero

  EXIT DEF IF argument = 0
  !Check for modulus equal to zero, modulus equal to absolute
  !value of argument, and modulus greater than absolute
  !value of argument.
```

```
  SELECT modulus
  CASE = 0%
      EXIT DEF
  CASE > ABS( argument )
      EXIT DEF
  CASE = ABS( argument )
      mdlo = argument
      EXIT DEF
  END SELECT

  !If argument is negative, set flag negative% and set argument
  !to its absolute value.
  IF argument < 0
     THEN argument = ABS( argument )
        negative%  = -1%
  END IF
  UNTIL argument < modulus
        argument = argument - modulus

        !If this calculation ever results in zero, mdlo returns zero
        IF argument = modulus
           THEN mdlo = 0
           EXIT DEF
        END IF
  NEXT

  !Argument now contains the right number, but the sign may be wrong.
  !If the negative argument flag was set, make the result negative.

  IF negative%
     THEN mdlo = - argument
     ELSE mdlo = argument
  END IF

END DEF

INPUT "PLEASE INPUT THE VALUE AND THE MODULUS"; X,Y
PRINT mdlo(X,Y)
END
```

Output

```
PLEASE INPUT THE VALUE AND THE MODULUS? 7, 5
 2
```

Because these functions are declared in DECLARE statements, the function names do not have to conform to the traditional VAX BASIC rules for naming functions.

Recursion occurs when a function calls itself. The following example defines a recursive function that returns a number's factorial value.

Example

```
DECLARE INTEGER FUNCTION factor ( INTEGER )
DEF INTEGER factor ( INTEGER F )
   IF F <= 0%
      THEN factor = 1%
      ELSE factor = factor(F - 1%) * F
   END IF
END DEF
INPUT "INPUT N TO FIND N FACTORIAL"; N%
PRINT "N! IS"; factor(N%)
END
```

Output

```
INPUT N TO FIND N FACTORIAL? 5
N! IS 120
```

Any variable accessed or declared in the DEF function and not in the formal parameter list is global to the program unit. When VAX BASIC evaluates the user-defined function, these global variables contain the values last assigned to them in the surrounding program module.

To prevent confusion, variables declared in the formal parameter list should not appear elsewhere in the program. Note that if your function definition actually uses global variables, these variables cannot appear in the formal parameter list.

You cannot transfer control into a multiline DEF function except by invoking it. You should not transfer control out of a DEF function except by way of an EXIT DEF or END DEF statement. This means that:

- If the DEF function contains an ON ERROR GOTO, GOTO, ON GOTO, GOSUB, ON GOSUB, or RESUME statement, that statement's target line number must also be in that DEF function.
- An ON ERROR GO BACK statement can transfer control out of a DEF function; however, a RESUME statement in an error handler outside the DEF function cannot transfer control back into the DEF function.
- If the DEF function contains a handler, and was invoked from a protected region, an EXIT HANDLER statement causes control to be transferred to the specified handler for that protected region. However, if the DEF function contains a handler but was not invoked from a protected region, an EXIT HANDLER statement causes control to be transferred to the default error handler.
- A subroutine cannot be shared by more than one DEF function. However, if you rewrite the subroutine as a DEF function with no parameters, other function definitions can share it.

A DEF function never changes the value of a parameter passed to it. Also, because formal parameters are local to the function definition, you cannot access the values of these variables from outside the DEF statement. These variable names are known only inside the DEF statement.

In the following example, the variable *first* is declared only in the function *fn_sum*. When VAX BASIC sees the second PRINT statement, it assumes that *first* is a new variable that is not declared in the main program. If you try to run this example, VAX BASIC signals the error "Explicit declaration of first required". If you do not specify the OPTION TYPE = EXPLICIT statement, VAX BASIC assumes that *first* is a new variable and initializes it to zero.

Example

```
OPTION TYPE = EXPLICIT
DECLARE INTEGER A, B
DEF fn_sum(INTEGER first, INTEGER second) = first + second
A = 50
B = 25
PRINT fn_sum(A, B)
PRINT first
END
```

Chapter 13

String Handling

This chapter defines dynamic and fixed-length strings and string virtual arrays, explains which you should choose for your application, and shows you how to use them.

13.1 Introduction

A string is a sequence of ASCII characters. VAX BASIC allows you to use three types of strings:

- Dynamic strings
- Fixed-length strings
- String virtual arrays

Dynamic strings are strings whose length can change during program execution. The length of a dynamic string variable may or may not change, depending on the statement used to modify it.

Fixed-length strings are strings whose length never changes. In other words, their length remains static. String constants are always fixed-length. String variables can be either fixed-length or dynamic. A string variable is fixed-length if it is named in a COMMON, MAP, or RECORD statement. If a string variable is not part of a map or common block, RECORD, or virtual array, it is a dynamic string. When a string variable is fixed-length, its length does not change, regardless of the statement you use to modify it. Table 13–1 provides more information on string modification.

Strings in virtual arrays have both fixed-length and dynamic attributes. String virtual arrays have a specified maximum length between 0 and 512 characters. During program execution, the length of an element in a string virtual array can change; however, the length is always between 0

and the maximum string size specified when the array was created. See Section 13.4 and Chapter 15 for more information about virtual arrays.

Table 13–1: String Modification

Statement	Changes Made to Fixed-Length Strings	Changes Made to Dynamic Strings
LET	Value	Value and length
LSET	Value	Value
RSET	Value	Value
Terminal I/O Statements[1]	Value	Value and length

[1]Terminal I/O statements include INPUT, INPUT LINE, LINPUT, MAT INPUT, and so on.

13.2 Using Dynamic Strings

Although dynamic strings are less efficient than fixed-length strings, they are often more flexible. For example, to concatenate strings, you can just use the LET statement to assign the concatenated value to a dynamic string variable, without having to be concerned about VAX BASIC truncating the string or adding trailing spaces to it. However, if the destination variable is fixed-length, you must make sure that it is long enough to receive the concatenated string, or VAX BASIC truncates the new value to fit the destination string. Similarly, if you use LSET or RSET to concatenate strings, you must ensure that the destination variable is long enough to receive the data.

The LET, LSET, and RSET statements all operate on dynamic strings as well as fixed-length strings. The LET statement can change the length of a dynamic string; LSET and RSET do not. LSET and RSET are more efficient than LET when changing the value of a dynamic string. For more information on LSET and RSET, see Sections 13.5.2 and 13.5.3.

In the following example, the first line assigns the value "ABC" to *A$*, the second line assigns "XYZ" to *B$*, and the third line assigns six spaces to *C$*. These variables are dynamic strings. In the fourth line, LSET assigns *A$* the value of *A$* concatenated with *B$*. Because the LSET statement does not change the length of the destination string variable, only the first three characters of the expression *A$* + *B$* are assigned to *A$*. The fifth line

uses LSET to assign *C$* the value of *A$* concatenated with *B$*. Because *C$* already has a length of 6, this statement assigns the value "ABCXYZ" to it.

Example

```
LET A$ = "ABC"
LET B$ = "XYZ"
LET C$ = "      "
LSET A$ = A$ + B$
LSET C$ = A$ + B$
PRINT A$
PRINT C$
END
```

Output

```
ABC
ABCXYZ
```

Like the LET statement, the INPUT, INPUT LINE, and LINPUT statements can change the length of a dynamic string, but they cannot change the length of a fixed-length string.

In this example, the first line assigns the null string to variable *A$*. The second line uses the LEN function to show that the null string has a length of zero. The third line uses the INPUT statement to assign a new value to *A$*, and the fourth and fifth lines print the new value and its length.

Example

```
!Declare a dynamic string
LET A$ = ""
PRINT LEN(A$)
INPUT A$
PRINT A$
PRINT LEN(A$)
END
```

Output

```
 0
? THIS IS A TEST
THIS IS A TEST
 14
```

You should not confuse the null string with a null character. A null character is one whose ASCII numeric code is zero. The null string is a string whose length is zero.

13.3 Using Fixed-Length Strings

It is generally more efficient to manipulate a fixed-length string than a dynamic string. Creating or modifying a dynamic string often causes VAX BASIC to create new storage, and this increases processor overhead. Modifying fixed-length strings involves less overhead because VAX BASIC manipulates existing storage using VAX character instructions.

If a string variable is part of a map or common block, or virtual array, a LET, INPUT, LINPUT, or INPUT LINE statement changes its value, but not its length. In the following example, the MAP statement in the first line explicitly assigns a length to each string variable. Because the LINPUT statements cannot change this length, VAX BASIC truncates values to fit the *address* and *city_state* variables. Because the *zip* variable is longer than the assigned value, VAX BASIC left-justifies the assigned value and pads it with spaces. The sixth line uses the compile-time constant HT (horizontal tab) to separate fields in the employee record.

Example

```
MAP (FIELDS) STRING full_name = 10,                                 &
            address = 10,                                           &
            city_state = 10,                                        &
            zip = 10
LINPUT "NAME"; full_name
LINPUT "ADDRESS"; address
LINPUT "CITY AND STATE"; city_state
LINPUT "ZIP CODE"; zip
EMPLOYEE_RECORD$ = full_name + HT + address + HT &
                   + city_state + HT + zip
PRINT EMPLOYEE_RECORD$
END
```

Output

```
NAME? JOE SMITH
ADDRESS? 66 GRANT AVENUE
CITY AND STATE? NEW YORK NY
ZIP? 01001

JOE SMITH           66 GRANT A   NEW YORK N 01001
```

13.4 Using String Virtual Arrays

Virtual arrays are stored on disk. You create a virtual array by opening a disk file and then using the DIM # statement to dimension the array on the open channel. This section describes only string virtual arrays. See Chapter 15 for more information on virtual arrays.

Elements of string virtual arrays behave much like dynamic strings, with two exceptions:

- When you create the virtual string array, you specify a maximum length for the array's elements. The length of an array element can never exceed this maximum. If you do not supply a length, the default is 16 characters.
- A string virtual array element cannot contain trailing nulls.

When you assign a value to a string virtual array element, VAX BASIC pads the value with nulls, if necessary, to fit the length of the virtual array element. However, when you retrieve the virtual array element, VAX BASIC strips all trailing nulls from the string. Therefore, when you access an element in a string virtual array, the string never has trailing nulls.

In the following example, the first two lines dimension a string virtual array and open a file on channel #1. The third line assigns a 10-character string to the first element of this string array, and to the variable *A$*. This 10-character string consists of "ABCDE" plus five null characters. The PRINT statements show that the length of *A$* is 10, while the length of *test(1)* is only 5 because VAX BASIC strips trailing nulls from string array elements.

Example

```
DIM #1%, STRING test(5)
OPEN "TEST" AS FILE #1%, ORGANIZATION VIRTUAL
A$, test(1%) = "ABCDE" + STRING$(5%, 0%)
PRINT "LENGTH OF A$ IS: "; LEN(A$)
PRINT "LENGTH OF TEST(1) IS: "; LEN(test(1%))
END
```

Output

```
LENGTH OF A$ IS: 10
LENGTH OF TEST(1) IS: 5
```

Although the storage for string virtual array elements is fixed, the length of a string array element can change because VAX BASIC strips the trailing nulls whenever it retrieves a value from the array.

13.5 Assigning String Data

To assign string data, you use the LET, LSET, RSET, and MID$ statements. The following sections describe how to use these statements.

13.5.1 The LET Statement

The LET statement assigns string data to a string variable. The keyword LET is optional. Again, LSET is more efficient than LET when changing a dynamic string variable. In the following example, *B* is a string variable and "ret_status" is a quoted string expression:

```
LET B = "ret_status"
```

The LET statement changes the length of dynamic strings but does not change the length of fixed-length strings. For instance, the following example, first creates a fixed-length string named *ABC* by declaring the string in a MAP statement. The program then creates a dynamic string named *XYZ* by declaring it in a DECLARE statement. The third line assigns a 3-character value to both variable *ABC* and *XYZ*, then prints the value and the length of the string variables. Variable *ABC* continues to have a length of 10: the three characters assigned, plus seven spaces for padding. The length of the dynamic variable changes with the values assigned to it.

Example

```
MAP (TEST) STRING ABC = 10
DECLARE STRING XYZ
ABC = "ABC"
XYZ = "XYZ"
PRINT ABC, LEN(ABC)
PRINT XYZ, LEN(XYZ)
ABC = "A"
XYZ = "X"
PRINT ABC, LEN(ABC)
PRINT XYZ, LEN(XYZ)
```

Output

```
ABC           10
XYZ           3
A             10
X             1
```

13.5.2 The LSET Statement

The LSET statement left-justifies data and assigns it to a string variable, without changing the variable's length. In the following example, *ABC* is a string variable and "ABC" is a string constant:

```
LSET ABC = "ABC"
```

If the string expression's value is shorter than the string variable's current length, LSET left-justifies the expression and pads the string variable with spaces. In the following example, the LET statement creates the 5-character string variable *test$*. The LSET statement in the second line assigns the string XYZ to the variable *test$* but does not change the length of *test$*. Because *test$* has a length of 5, the LSET statement pads the string XYZ with two spaces when assigning the value. The PRINT statement shows that test$ includes these two spaces.

Example

```
LET test$ = "ABCDE"
LSET test$ = "XYZ"
PRINT "'"; test$; "'"
END
```

Output

```
'XYZ  '
```

LSET left-justifies a string expression longer than the string variable and truncates it on the right as shown in the following example.

Example

```
LET test$ = "ABCDE"
LSET test$ = "12345678"
PRINT test$
END
```

Output

```
12345
```

The LET statement creates the 5-character string variable *test$*. The LSET statement in the second line assigns the characters "12345" to *test$*. Because LSET does not change the string variable's length, it truncates the last three characters (678).

13.5.3 The RSET Statement

The RSET statement right-justifies data and assigns it to a string variable without changing the variable's length. In the following example, *C_R* is a string variable and "cust_rec" is a string constant.

```
RSET C_R = "cust_rec"
```

RSET right-justifies a string expression shorter than the string variable and pads it with spaces on the left. In the following example, the LET statement creates the 5-character string variable *test$*. The RSET statement in the second line assigns the string XYZ to *test$* but does not change the length of *test$*. Because *test$* is five characters long, the RSET statement pads XYZ with two spaces when assigning the value. The PRINT statement shows that *test$* includes these two spaces.

Example

```
LET test$ = "ABCDE"
RSET test$ = "XYZ"
PRINT "'" ;  test$; "'"
END
```

Output

```
'  XYZ'
```

If the string expression's value is longer than the string variable, RSET right-justifies the string expression and truncates characters on the left to fit the string variable as shown in the following example.

Example

```
LET test$ = "ABCDE"
RSET test$ = "987654321"
PRINT test$
END
```

Output

```
54321
```

The LET statement creates a 5-character string variable, *test$*. The RSET statement assigns "54321" to *test$*. RSET, which does not change the variable's length, truncates "9876" from the left side of the string expression.

Note that, when using LSET and RSET, padding can become part of the data.

Example

```
LET A$ = '12345'
LSET A$ = 'ABC'
LET B$ = '12345678'
RSET B$ = A$
PRINT "'";B$;"'"
```

Output

```
'   ABC  '
```

13.5.4 The MID$ Assignment Statement

You can replace a portion of a string with another string using the MID$ assignment statement. You specify a starting character position that indicates where to begin the substitution. If you specify a starting character position that is less than 1, VAX BASIC assumes a starting character position of 1. In addition, you can optionally specify the number of characters to substitute from the source string expression. If you do not specify the number of characters to substitute, VAX BASIC attempts to insert the entire source expression. However, the MID$ statement never changes the length of the target string variable; therefore, the entire source expression may not fit into the available space.

The following example illustrates the use of MID$ as an assignment statement. In this example, "ABCD" is the input string, the starting character position is 1, and the length of the segment to be replaced is 3 characters. Note that when you use MID$ as an assignment statement, the length of the input string does not change. Therefore, the length of the result ("123D"), is equal to the length of the input string.

Example

```
DECLARE STRING old_string, replace_string
old_string = "ABCD"
replace_string = "123"
PRINT old_string
MID$(old_string,1,3) = replace_string
PRINT old_string
```

Output

```
ABCD
123D
```

Keep these considerations in mind when you use the MID$ assignment statement:

- The length argument is optional. If not specified, the number of characters replaced will be the minimum of the length of the replacement string and the length of the input string minus the starting position value.
- If the length of the segment is less than or equal to zero, VAX BASIC assumes a length of zero.
- The length of the input string does not change regardless of the value of the length of the segment.

13.6 Manipulating String Data with String Functions

When used with the LET statement, VAX BASIC string functions let you manipulate and modify strings. These functions let you:

- Determine the length of a string (LEN)
- Search for the position of a set of characters in a string (POS)
- Extract segments from a string (SEG$, MID$)
- Create a string of any length, made up of any single character (STRING$)
- Create a string of spaces (SPACE$)
- Remove trailing spaces and tabs from a string (TRM$)
- Edit a string (EDIT$)

These functions are discussed in the following sections. See the *VAX BASIC Reference Manual* for more information about each string function.

13.6.1 The LEN Function

The LEN function returns the number of characters in a string as an integer value. For example:

```
LEN(spec)
```

Spec is a string expression. The length of the string expression includes leading and trailing blanks. In the following example, the variable Z$ is set equal to "ABC XYZ", which has a length of eight.

Example

```
alpha$ = "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
PRINT LEN(alpha$)
Z$ = "ABC" + "  " + ""XYZ"
PRINT LEN(Z$)
END
```

Output

```
 26
 8
```

13.6.2 The POS Function

POS searches a string for a group of characters (a substring). In the following example, *spec* is the string to be searched, *test* is the substring for which you are searching and *15* is the character position where VAX BASIC starts the search:

```
POS(spec,test,15)
```

The position returned by POS is relative to the beginning of the string, not the starting position of the search. For example, if you search the string "ABCDE" for the substring "E", it does not matter whether you specify a starting position of 1, 2, 3, 4, or 5, VAX BASIC still returns the value 5 as the position where the substring was found.

If the function finds the substring, it returns the position of the substring's first character. Otherwise, it returns zero as in the following example.

Example

```
alpha$ = "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
Z$ = "DEFG"
X% = POS(ALPHA$,Z$,1%)
PRINT X%
Q$ = "TEST"
Y% = POS(ALPHA$, Q$, 1%)
PRINT Y%
END
```

Output

```
 4
 0
```

If you specify a starting position other than 1, VAX BASIC still returns the position of the substring relative to the beginning of the string as shown in the following example.

Example

```
alpha$ = "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
Z$ = "HIJ"
PRINT POS(ALPHA$, Z$, 7%)
END
```

Output

```
8
```

If you know that the substring is not near the string's beginning, specifying a starting position greater than one speeds program execution by reducing the number of characters VAX BASIC must search.

You can use the POS function to associate a character string with an integer that you can then use in calculations. This technique is called a *table look-up*. For instance, the following example prompts for a 3-character string, changes the string to uppercase letters, and searches the table string to find a match. The WHILE loop executes indefinitely until a carriage return is typed in response to the prompt.

Example

```
DECLARE STRING CONSTANT table =    &
 "JANFEBMARAPRMAYJUNJULAUGSEPOCTNOVDEC"
DECLARE STRING month, UPPER_CASE_MONTH, message
DECLARE INTEGER month_length
DECLARE REAL month_pos
PRINT "Please type the first three letters of a month"
PRINT "To end the program, type only RET";
Loop_1:
   WHILE 1% = 1%
      INPUT month
      UPPER_CASE_MONTH = EDIT$(month, 32%)
      month_length = LEN(UPPER_CASE_MONTH)
      EXIT Loop_1 IF month_length = 0%
      IF month_length = 3%
        THEN month_pos = (POS(table, UPPER_CASE_MONTH, 1) + 2) / 3
          IF (month_pos = 0%) OR (month_pos <> FIX(month_pos))
               THEN MESSAGE = " Invalid abbreviation, try again"
               ELSE MESSAGE = " is month number" + NUM$(MONTH_POS)
          END IF
        ELSE MESSAGE = " Abbreviation not three characters, try again"
      END IF
      PRINT month; message
   NEXT
END
```

Output

```
Please type the first three letters of a month
To end the program, type only RET? Nov
Nov is month number 11
```

Keep these considerations in mind when you use POS:

- If you specify a starting position less than 1, POS assumes a starting position of one.
- If you specify a starting position greater than the searched string's length, POS returns a zero (unless the substring is null).

- When searching for a null string:
  - If you specify a starting position greater than the string's length, POS returns the string's length plus one.
  - If the string to be searched is also null, POS returns a value of one.
  - If the specified starting position is less than or equal to 1, POS returns a value of one.
  - If the specified starting position is greater than one and less than or equal to the string's length plus 1, POS returns the specified starting position.

Note that searching for a null string is not the same as searching for the null character. A null string has a length of zero, while the null character has a length of one. The null character is an ASCII character whose value is zero.

13.6.3 The SEG$ Function

The SEG$ function extracts a segment (substring) from a string. The original string remains unchanged. In the following example, *time* is the input string, *13* is the position of the first character extracted, and *16* is the position of the last character extracted:

```
SEG$(time,13,16)
```

SEG$ extracts from the input string the substring that starts at the first character position, up to and including the last character position. It returns the extracted segment.

Example

```
PRINT SEG$("ABCDEFG", 3%, 5%)
END
```

Output

```
CDE
```

If you specify character positions that exist in the string, the length of the returned substring always equals (int-exp2 – int-exp1 + 1).

Keep these considerations in mind when you use SEG$:

- If the starting character position is less than 1, VAX BASIC assumes a value of 1.
- If the starting character position is greater than the ending character position, or the length of the string, SEG$ returns a null string.

- If the ending character position is greater than the length of the string, SEG$ returns all characters from the starting character position to the end of the string.
- If the starting character position is equal to the ending character position, SEG$ returns the character at the starting position.

You can replace part of a string by using the SEG$ function with the string concatenation operator (+). In the following example, when VAX BASIC creates *C$*, it concatenates the first two characters of *A$*, the 3-letter string XYZ, and the last two characters of *A$*. The original contents of *A$* do not change.

Example

```
A$ = "ABCDEFG"
C$ = SEG$(A$, 1%, 2%) + "XYZ" + SEG$(A$, 6%, 7%)
PRINT C$
PRINT A$
END
```

Output

```
ABXYZFG

ABCDEFG
```

You can use similar string expressions to replace characters in any string. If you do not change the length of the target string, use the MID$ assignment statement to perform string replacement. A general formula to replace characters in positions *n* through *m* of string A$ with characters in B$ is:

C$ = SEG$(A$,1%,n–1) + B$ + SEG$(A$,m+1,LEN(A$))

The following example replaces the sixth through ninth characters of the string “ABCDEFGHIJK” with “123456”.

Example

```
A$ = "ABCDEFGHIJK"
B$ = "123456"
C$ = SEG$(A$,1%,5%) + B$ + SEG$(A$,10%,LEN(A$))
PRINT C$
PRINT A$
PRINT B$
END
```

Output

```
ABCDE123456JK
ABCDEFGHIJK
123456
```

The following formulas are more specific applications of the general formula.

- To replace the first n characters of A$ with B$ use

  C$ = B$ + SEG$(A$,n+1,LEN(A$))
- To replace all but the first n characters of A$ with B$ use

  C$ = SEG$(A$,1,n) + B$
- To replace all but the last n characters of A$ with B$ use
  C$ = B$ + SEG$(A$,(LEN(A$)–n) + 1, LEN(A$))
- To replace the last n characters of A$ with B$ use

  C$ = SEG$(A$,1,LEN(A$)–n) + B$
- To insert B$ in A$ after the nth character in A$ use

  C$ = SEG$(A$,1,n) + B$ + SEG$(A$,n+1,LEN(A$))

13.6.4 The MID$ Function

The MID$ function *extracts* a specified substring, beginning at a specified character position and ending at a specified length. If you specify a starting character position that is less than 1, VAX BASIC automatically assumes a starting character position of 1.

In the following example, the MID$ function uses the input string "ABCD", and extracts a segment consisting of 3 characters. Because VAX BASIC automatically assumes a starting character position of 1 when the specified starting character position is less than 1, the string that is extracted begins with the first character of the input string.

Example

```
DECLARE STRING old_string, new_string
old_string = "ABCD"
new_string = MID$(old_string, 0, 3)
PRINT new_string
```

Output

```
ABC
```

Keep these considerations in mind when you use the MID$ function:

- If the position of the segment's first character is greater than the input string, MID$ returns a null string.
- If the length of the segment is greater than the length of the input string, VAX BASIC returns the string that begins at the specified starting character position and includes all characters remaining in the string.
- If the length of the segment is less than or equal to zero, MID$ returns a null string.
- If you specify a floating-point expression for the position of the segment's first character or for the length of the segment, VAX BASIC truncates it to a long integer.

13.6.5 The STRING$ Function

The STRING$ function creates a character string containing multiple occurrences of a single character. In the following example, 23 is the length of the returned string and 30 is the ASCII value of the character that makes up the string. This value is treated modulo 256.

```
STRING$(23,30)
```

The following example creates a 10-character string containing uppercase As, which have ASCII value 65.

Example

```
out$ = STRING$(10%, 65%)
PRINT out$
END
```

Output

```
AAAAAAAAAA
```

Keep these considerations in mind when you use the STRING$ function:

- If the length of the returned string is less than or equal to zero, STRING$ returns a null string.
- If the length of the returned string is greater than 65535, VAX BASIC signals an error.

13.6.6 The SPACE$ Function

The SPACE$ function creates a character string containing spaces. In this example, *5* is the number of spaces in the string:

```
SPACE$(5)
```

The following example creates a 9-character string which contains 3 spaces.

Example

```
A$ = "ABC"
B$ = "XYZ"
PRINT A$ + SPACE$(3%) + B$
END
```

Output

```
ABC   XYZ
```

13.6.7 The TRM$ Function

The TRM$ function removes trailing blanks and tabs from a string. The input string remains unchanged. In the following example, all trailing blanks that appear in the string expression "ABCDE " are removed once the TRM$ function is invoked.

Example

```
A$ = "ABCDE    "
B$ = "XYZ"
first$ = A$ + B$
second$ = TRM$(A$) + B$
PRINT first$
PRINT second$
END
```

Output

```
ABCDE    XYZ
ABCDEXYZ
```

The TRM$ function is especially useful for extracting the nonblank characters from a fixed-length string (for example, a COMMON or MAP, or a parameter passed from a program written in another language).

13.6.8 The EDIT$ Function

The EDIT$ function performs one or more string editing functions, depending on the value of an argument you supply. The input string remains unchanged. In the following example, *stu_rec* is a string expression and *32* determines the editing function performed:

```
EDIT$(stu_rec,32)
```

Table 13–2 shows the action VAX BASIC takes for a given value of the integer expression.

Table 13–2: EDIT$ Options

Value of Expression	Effect
1	Discards each character's parity bit (bit 7). Note that you should not use this value for characters in the DEC Multinational Character Set.
2	Discards all spaces and tabs.
4	Discards all carriage returns, line feeds, form feeds, deletes, escapes, and nulls.
8	Discards leading spaces and tabs.
16	Converts multiple spaces and tabs to a single space.
32	Converts lowercase letters to uppercase.
64	Converts left brackets ([ ) to left parentheses [(], and right brackets ( ]) to right parentheses [)].
128	Discards trailing spaces and tabs. (Same as TRM$ function.)
256	Suppresses all editing for characters within quotation marks. If the string has only one quotation mark, VAX BASIC suppresses all editing for the characters following the quotation mark.

All values are additive; for example, by specifying 168, you can:

- Discard leading spaces and tabs (value 8)
- Convert lowercase letters to uppercase (value 32)
- Discard trailing spaces and tabs (value 128)

The following program requests an input string, discards all spaces and tabs, converts lowercase letters to uppercase, and converts brackets to parentheses.

Example

```
LINPUT "PLEASE TYPE A STRING";input_string$
new_string$ = EDIT$(input_string$, 2% + 32% + 64%)
PRINT new_string$
END
```

Output

```
PLEASE TYPE A STRING? 88  abc[TAB][5,5]
88ABC(5,5)
```

13.7 Manipulating String Data with Multiple Maps

Mapping a string storage area in more than one way lets you extract a substring from a string or concatenate strings. In the following example, the three MAP statements reference the same 108 bytes of data.

Example

```
MAP (emprec) first_name$ = 10,                        &
             last_name$ = 20,                         &
             street_number$ = 6,                      &
             street$ = 15,                            &
             city$ = 20,                              &
             state$ = 2,                              &
             zip$ = 5,                                &
             wage_class$ = 2,                         &
             date_of_review$ = 8,                     &
             salary_ytd$ = 10,                        &
             tax_ytd$ = 10
MAP (emprec) full_name$ = 30,                         &
             address$ = 48,                           &
             salary_info$ = 30
MAP (emprec) employee_record$ = 108
```

You can move data into a map in different ways. For instance, you can use terminal input, arrays, and files. In the following example, the READ and DATA statements are used to move data into a map.

Example

```
READ EMPLOYEE_RECORD$
DATA "WILLIAM   DAVIDSON           2241  MADISON BLVD   " &
"SCRANTON           PA14225A912/10/78$13,325.77$925.31"
```

Because all the MAP statements in the previous example reference the same storage area *(emprec)*, you can access parts of this area through the mapped variables as shown in Example 1 and Example 2.

Example 1

```
PRINT full_name$
PRINT wage_class$
PRINT salary_ytd$
```

Output 1

```
WILLIAM   DAVIDSON
A9
$13,325.77
```

Example 2

```
PRINT last_name$
PRINT tax_ytd$
```

Output 2

```
DAVIDSON
$925.31
```

You can assign a new value to any of the mapped variables. For instance, the following example prompts the user for changed information by displaying a menu of topics. The user can then choose which topics need to be changed and then separately assign new values to each variable.

Example

```
Loop_1:
WHILE 1% = 1%
      INPUT "Changes? (please type YES or NO)"; CH$
      EXIT Loop_1 IF CH$ = "NO"
      PRINT "1. FIRST NAME"
      PRINT "2. LAST NAME"
      PRINT "3. STREET NUMBER"
      PRINT "4. STREET"
      PRINT "5. CITY"
      PRINT "6. STATE"
      PRINT "7. ZIP"
      PRINT "8. WAGE CLASS"
      PRINT "9. DATE OF REVIEW"
      PRINT "10. SALARY YTD"
      PRINT "11. TAX YTD"
      INPUT "CHANGE NUMBER"; NUMBER%
```

```
        SELECT NUMBER%
        CASE 1%
             INPUT "FIRST NAME"; first_name$
        CASE 2%
             INPUT "LAST NAME"; last_name$
        CASE 3%
             INPUT "STREET NUMBER"; street_number$
        CASE 4%
             INPUT "STREET"; street$
        CASE 5%
             INPUT "CITY"; city$
        CASE 6%
            INPUT "STATE"; state$
        CASE 7%
             INPUT "ZIP CODE"; zip$
        CASE 8%
             INPUT "WAGE CLASS"; wage_class$
        CASE 9%
             INPUT "DATE OF REVIEW"; date_of_review$
        CASE 10%
             INPUT "SALARY YTD"; salary_ytd$
        CASE 11%
             INPUT "TAX YTD"; tax_ytd$
        CASE ELSE
             PRINT "Invalid choice"
        END SELECT
NEXT
END
```

Output

```
Changes? (please type YES or NO)? YES
1.   FIRST NAME
2.   LAST NAME
3.   STREET NUMBER
4.   STREET
5.   CITY
6.   STATE
7.   ZIP
8.   WAGE CLASS
9.   DATE OF REVIEW
10.   SALARY YTD
11.   TAX YTD

CHANGE NUMBER? 10
SALARY YTD? 14,277.08
Changes? (please type YES or NO)? YES
CHANGE NUMBER? 11
TAX YTD? 998.32
Changes? (please type YES or NO)? NO
```

See Chapter 9 and the *VAX BASIC Reference Manual* for more information on the MAP statement.

Chapter 14

Program Segmentation

Program segmentation is the process of dividing a program into small, manageable routines and modules. In a segmented or *modular* program, each routine or module usually performs only one logical function. You can therefore design and implement a modular program faster than a nonsegmented program. Program modularity also simplifies debugging and testing, as well as program maintenance and transportability.

This chapter describes how to:

- Declare VAX BASIC subprograms
- Write VAX BASIC subprograms
- Share data among program units

Subprograms processed by the VAX BASIC compiler conform to the VAX Procedure Calling Standard. This standard prescribes how arguments are passed, how values are returned, and how procedures receive and return control. Because VAX BASIC conforms to the VAX Procedure Calling Standard, a VAX BASIC subprogram or main program can call or be called by any procedure written in a language that also conforms to this standard. For information about calling non-BASIC procedures, see Chapter 21.

14.1 VAX BASIC Subprograms

VAX BASIC has SUB, FUNCTION, and PICTURE subprograms. Each of these subprograms receives parameters and can modify parameters passed by reference or by descriptor. The differences between SUB, FUNCTION, and PICTURE subprograms are as follows:

- FUNCTION subprograms must be declared with an EXTERNAL statement in the calling program. Declaring SUB and PICTURE subprograms is optional.

- FUNCTION subprograms return a value; SUB and PICTURE subprograms do not.
- PICTURE subprograms must be invoked with the DRAW statement and are reserved for use with VAX BASIC graphics. For more information on PICTURE subprograms, see *Programming with VAX BASIC Graphics*.

All subprograms invoked by a VAX BASIC program must have unique names. A VAX BASIC program cannot have different subprograms with the same identifiers.

Subprograms can return a value to the calling program by way of parameters. You can use subprograms to separate routines that you commonly use. For example, you can use subprograms to perform file I/O operations, to sort data, or for table lookups.

You can also use subprograms to separate very large programs into smaller, more manageable routines, or you can separate modules that are modified often. If all references to system-specific features are isolated, it is easier to transport the program to a different system. VMS System Services and VAX Run-Time Library routines are specific to VMS systems; therefore, you should consider isolating references to them in subprograms. Chapter 21 describes how to access Run-Time Library routines and system services from VAX BASIC.

You should also consider isolating complex processing algorithms that are used commonly. If complex processing routines are isolated, they can be shared by many programs while the complexity remains hidden from the main program logic. However, they can share data only if the data is:

- Passed as a parameter from the CALL statement or function invocation to the subprogram—see Section 14.2
- Part of a MAP or COMMON block—see Chapter 8 for information about using MAP and COMMON statements
- In a file—see Chapter 15 for more information about accessing data from a file

All DATA statements are local to a subprogram. Each time you call a subprogram, VAX BASIC positions the data pointer at the beginning of the subprogram's data.

The data pointer in the main program is not affected by READ or RESTORE statements in the subprogram (in contrast with the RESTORE # statement, which resets record pointers to the first record in the file no matter where it is executed). Chapter 7 contains more information on the READ and RESTORE statements. For more information on the RESTORE # statement, see Chapter 15.

14.1.1 SUB Subprograms

A SUB subprogram is a program module that can be separately compiled and that cannot return a value. A SUB subprogram is delimited by the SUB and END SUB statements. You may use the EXTERNAL statement to explicitly declare the SUB subprogram.

The END SUB statement does the following:

- Marks the end of the SUB subprogram
- Does not affect I/O operations or files
- Releases the storage allocated to local variables
- Returns control to the calling program

The EXIT SUB statement transfers control to the statement lexically following the statement that invoked the subprogram. It is equivalent to an unconditional branch to an END SUB statement.

The following SUB subprogram sorts two integers. If this SUB is invoked with actual parameter values that are already in sorted order, the EXIT SUB statement is executed and control returns to the calling program.

```
SUB sort_out (INTEGER X, INTEGER Y)
DECLARE INTEGER temp
  IF X > Y
   THEN
      temp = X
      X = Y
      Y = temp
   ELSE
      EXIT SUB
   END IF
END SUB
```

14.1.2 FUNCTION Subprograms

A FUNCTION subprogram is a program module that returns a value and can be separately compiled. It must be delimited by the FUNCTION and END FUNCTION statements. You use the EXTERNAL statement to name and explicitly declare the data type of an external function.

The END FUNCTION statement does the following:

- Marks the end of a function subprogram
- Does not affect I/O operations or files
- Releases the storage allocated to local variables

- Optionally specifies a return value for the function
- Returns control to the calling program

The EXIT FUNCTION statement immediately returns program control to the statement that invoked the function and optionally returns the function's return value. It is equivalent to an unconditional transfer to the END FUNCTION statement.

You can specify an expression with both the END FUNCTION and EXIT FUNCTION statements, which is another way of returning a function value. This expression must match the function data type, and it supersedes any function assignment. For more information, see the *VAX BASIC Reference Manual*.

The following function returns the volume of a sphere of radius *R*. If this function is invoked with an actual parameter value less than or equal to zero, the function returns zero.

Example

```
FUNCTION REAL Sphere_volume (REAL R)
     IF R <= 0
       THEN
           Sphere_volume = 0.0
       ELSE
           Sphere_volume = 4/3 * PI * R ** 3
      END IF
END FUNCTION
```

The following example declares the FUNCTION subprogram and invokes it.

Example

```
PROGRAM call_sphere
  EXTERNAL REAL FUNCTION SPHERE_VOLUME(REAL)
  PRINT  SPHERE_VOLUME(5.925)
END PROGRAM
```

Note that this module is compiled separately from the FUNCTION subprogram. You can link these modules together to run the program from DCL level. To run the program in the BASIC environment, you follow these steps:

1. Compile the function subprogram
2. Load the resulting object module with the LOAD command
3. Read in the main program with the OLD command
4. Type RUN

See Chapter 3 for more information about the LOAD command and linking and running multiple-unit programs.

14.2 Declaring Subprograms and Parameters

You declare a subprogram by naming it in an EXTERNAL statement in the calling program. You may also declare the data type of each parameter. If the subprogram is a function, the EXTERNAL statement also lets you specify the data type of the returned value.

The following statements are sample subprogram declarations using the EXTERNAL statement:

```
EXTERNAL SUB my_sub (LONG, STRING)
EXTERNAL GFLOAT FUNCTION my_func (GFLOAT, LONG, GFLOAT)
EXTERNAL REAL FUNCTION determinant (LONG DIM(,))
```

Note that the parameter lists contain only data type and dimension information; they cannot contain any format or actual parameters. When the external procedure is invoked, VAX BASIC ensures that the actual parameter data type matches the data type specified in the EXTERNAL declaration. However, VAX BASIC does not check to make sure that the parameters declared in the EXTERNAL statement match those in the external routine. You must ensure that these parameters match.

You can pass data of any VAX BASIC data type to a VAX BASIC subprogram, including RFAs and RECORDs. VAX BASIC allows you to pass up to 255 parameters, separated by commas. The data can be any one of the following:

- Constants
- Variables
- Expressions
- Functions
- Array elements
- Entire arrays (but not virtual arrays)

For passing constants, variables, functions, and array elements, you simply name them in the argument list. For example:

```
CALL SUB01(var1, var2)

CALL SUB02(Po_num%, Vouch, 66.67, Cust_list(5), FNA(B%))
```

However, when passing an entire array, you must use a special format. You specify the array name followed by commas enclosed in parentheses. The number of commas must be the number of array dimensions minus one. For example, *array_name()* is a one-dimensional array, *array_name(,)* is a

two-dimensional array, *array_name(,,)* signifies a three-dimensional array, and so on.

The following example creates a three-dimensional array, loads the array with values, and passes the array to a subprogram as a parameter. The subprogram can access and change values in array elements, and these changes remain in effect when control returns to the main program.

Example

```
PROGRAM fill_array
OPTION TYPE = EXPLICIT
DECLARE LONG I,J,K, three_d(10,10,10)
EXTERNAL SUB example_sub (LONG DIM(,,))
FOR I = 0 TO 10
    FOR J = 0 TO 10
        FOR K = 0 TO 10
            three_d(I,J,K) = I + J + K
        NEXT K
    NEXT J
NEXT I

CALL  example_sub( three_d(,,))
END PROGRAM

SUB example_sub( LONG X( , , ))
    .
    .
    .
END SUB
```

If you do not specify data types for parameters, the default data type is determined by:

- The last specified parameter data type
- An OPTION statement
- A VAX BASIC compilation qualifier (for example, /REAL_SIZE=DOUBLE)
- The system default

The last specified parameter data type overrides all the other default data types, the defaults specified in the OPTION statement override any compilation qualifiers and system defaults, and so on. See Chapter 3 for more information on the OPTION statement and establishing data type defaults.

When you know the length of a string or the dimensions of an array at compile time, you can achieve optimum performance, by passing them BY REF. When you call programs written in other languages, the practice of declaring subprograms and specifying the data types of parameters becomes more important because other languages may not use the VAX BASIC

default parameter-passing mechanisms. For more information on calling subprograms written in other languages, see Chapter 21.

14.3 Compiling Subprograms

A VAX BASIC source file can contain multiple program units. When you compile such a file, VAX BASIC produces a single object file containing the code from all the program units. You can then link this object file to create an executable image.

If the main program and subprograms are in separate source files, you can compile them separately from DCL level. For example, the following command causes VAX BASIC to create MAIN.OBJ, SUB1.OBJ, and SUB2.OBJ by separating the file names with commas:

```
$  BASIC main,sub1,sub2
```

To link these programs, you must specify all object files as input to the VMS Linker.

Alternatively, you can compile multiple modules into a single object file at DCL command level by separating the file names with plus signs:

```
$  BASIC main+sub1+sub2
```

The plus signs used to separate the file names cause VAX BASIC to create a single object file named MAIN.OBJ from the three source modules. To link this program, you specify only one input file to the linker. Note that you cannot concatenate source files that do not contain line numbers.

In the BASIC environment, you can compile multiple program units with a resulting single object file by using the APPEND command followed by the COMPILE command. For more information on the APPEND and COMPILE commands, see Chapter 3.

When creating a multiple-unit program, follow these rules:

- If the source file contains line numbers, then the line numbers for each subprogram must be numerically greater than the highest line number of all preceding subprograms.
- Line numbers must be unique and no greater than 32767.
- Each subprogram must end with an END SUB or END FUNCTION statement before the next subprogram begins.
- If the source file contains line numbers, then text following an END SUB or END FUNCTION statement must begin on a numbered line.

- If the source file does not contain line numbers, then text following an END SUB or END FUNCTION statement must begin on a new physical line.

Note that in a multiple-unit program that contains line numbers, any comments or statements following an END, END SUB, or END FUNCTION statement become part of the preceding subprogram unless they begin on a numbered line. In a multiple-unit program that does not contain line numbers, however, any comments following an END, END SUB, or END FUNCTION statement become part of the following subprogram if one exists.

In the following example, the function *Strip* changes all brackets to parentheses in the string *A$* or *alpha*, and strips all trailing spaces and tabs.

Example

```
PROGRAM scan
  EXTERNAL STRING FUNCTION Strip (STRING)
  A$ = "USER$DISK:[BASIC.TRYOUTS]"
  B$ = Strip( A$ )
  PRINT B$
END PROGRAM

FUNCTION STRING Strip( STRING alpha )
IF (POS( alpha, "[", 1%)) > 0%
   THEN Strip = EDIT$(alpha, 128% +64%)
   ELSE Strip = EDIT$(alpha, 128%)
END IF
END FUNCTION
```

14.4 Invoking Subprograms

The following sections describe the following:

- Invoke subprograms
- Pass parameters to subprograms
- Share data among program modules

14.4.1 Invoking SUB Subprograms

The CALL statement transfers control to a subprogram, and optionally passes arguments to it. The parameters in the CALL statement specify variables, constants, expressions, array elements, or entire arrays to be passed to the subprogram. You can also specify a function in the argument list; when you do this, VAX BASIC passes the value returned by the function to the subprogram. If possible, VAX BASIC converts the actual arguments to the data type specified in the EXTERNAL statement. VAX BASIC signals an error when the conversion is not possible.

The following example shows a VAX BASIC main program calling a VAX BASIC subprogram. The main program prompts for three integers: *A*, *B*, and *C*. It then passes these variables as parameters to the SUB subprogram. The subprogram prints the sum of these variables and returns control to the calling program.

Example

```
PROGRAM get_input
  OPTION TYPE = EXPLICIT
  EXTERNAL SUB SUB01(LONG, LONG, LONG)
  DECLARE LONG A, B, C
  INPUT "Please type three integers"; A, B, C
  CALL SUB01 (A, B, C)
END PROGRAM

SUB SUB01 (LONG X, LONG Y, LONG Z)
  PRINT "The sum is"; X + Y + Z
END SUB
```

14.4.2 Invoking FUNCTION Subprograms

The following example performs the same task as the example shown in Section 14.4.1; however, this example uses a FUNCTION subprogram that returns the value to the main program and the main program prints the result.

Example

```
PROGRAM invoke_funct
  EXTERNAL LONG FUNCTION FUN01(LONG, LONG, LONG)
  DECLARE LONG A, B, C
  INPUT "Please type three integers"; A, B, C
  PRINT "The sum is"; FUN01(A, B, C)
END PROGRAM

FUNCTION LONG FUN01 (LONG X, LONG Y, LONG Z)
  FUN01 =  X + Y + Z
END FUNCTION
```

If you do not assign a value to the function name and you do not specify a return value on an EXIT FUNCTION or END FUNCTION statement, the function returns zero or the null string.

Note that when writing FUNCTION subprograms, you must specify a data type for the function in both the main program EXTERNAL statement and the subprogram FUNCTION statement. This data type keyword specifies the data type of the value returned by the function subprogram. You should ensure that the data type specified in an EXTERNAL FUNCTION statement matches the data type specified in the FUNCTION statement.

If you declare a FUNCTION subprogram with an EXTERNAL statement and use the CALL statement to invoke the function, it executes correctly but the function value is not available. Note that VAX BASIC still performs parameter validation when you invoke a function with the CALL statement.

Note that you cannot use the CALL statement to invoke a string or packed decimal function.

14.5 Returning Program Status

A PROGRAM unit lets you return a status from a VAX BASIC image. To do this, you can optionally include an integer expression with the END PROGRAM and EXIT PROGRAM statements. After executing a program, you can examine this status by checking the DCL symbol $STATUS. By default, VAX BASIC returns a status of 1, indicating success. Success is signaled with an odd numbered status value, while an error is signaled with an even numbered value. $STATUS contains the same value as the integer expression for the exit status in the EXIT and END PROGRAM statements. Note that if a program is terminated with an EXIT PROGRAM statement, the expression on the EXIT PROGRAM statement overrides any expression on the END PROGRAM statement.

In the following example, *exit_status* contains the status value returned by the program. After program execution, $STATUS has the value of *exit_status*. You can examine the value of $STATUS and display the corresponding message text with the lexical function F$MESSAGE at DCL level, as shown following this example.

Example

```
PROGRAM Venture
  DECLARE INTEGER exit_status,                         &
          REAL capital
  EXTERNAL LONG CONSTANT SS$_BADPARAM
  EXTERNAL SUB play_safe(INTEGER),                     &
           minor_risk(INTEGER),major_risk(INTEGER)
  Exit_status = 1%
  SET NO PROMPT
  How_much:
  INPUT "Enter the amount of your free capital $";capital
  SELECT capital
     CASE = 0
             exit_status = SS$_BADPARAM
             EXIT PROGRAM exit_status
     CASE < 5000
             CALL play_safe(capital)
     CASE < 15000
             CALL minor_risk(capital)
     CASE < 50000
             CALL major_risk(capital)
     CASE ELSE
             PRINT "I can't cope with that amount, try again."
  END SELECT
  GOTO How_much
   .
   .
   .
END PROGRAM exit_status
```

After program execution, you can examine the status of the program at DCL level:

```
$ SHOW SYMBOL $STATUS
  $STATUS = "%X10"
$ error_text = F$MESSAGE(%X10)
$ SHOW SYMBOL error_text
  ERROR_TEXT = "SYSTEM-W-BADPARAM, bad parameter value"
```

The PROGRAM statement is always optional; EXIT PROGRAM and END PROGRAM are legal without a matching PROGRAM statement. Without a PROGRAM statement, these statements still exit the main compilation unit. The EXIT PROGRAM and END PROGRAM statements are not valid within SUB, FUNCTION, or PICTURE subprograms.

Chapter 15

File Input and Output

This chapter explains the VAX BASIC file organizations and record operations that are implemented through VAX Record Management Services (VAX RMS). For a more thorough understanding of file organization and file and record operations, see the *VMS Record Management Services Manual.*

RMS stores data in physical *blocks*. A block is the smallest number of bytes VAX BASIC transfers in a read or write operation. On disk, a block is 512 bytes. On magnetic tape, it is between 18 and 8192 bytes.

RMS stores one or more *data records* in each block. A data record can also be divided into smaller units, called *fields*. A data record can be smaller than, equal to, or larger than a disk block.

15.1 Record Formats

The format of a record determines how RMS stores the record in a block. You specify the record format in an OPEN statement. The following are valid VAX BASIC record formats:

- Fixed-length records
- Variable-length records
- Stream records

15.1.1 Fixed-Length Records

Fixed-length records are all the same length. RMS stores fixed-length records as they appear in the record buffer, including any spaces or null characters following the data; this process is called padding. Processing these records involves less overhead than other record formats; however, this format can use disk storage space less efficiently than variable-length or stream records.

15.1.2 Variable-Length Records

Variable-length records can have different lengths, but no record can exceed a maximum size set for the file. When the record is written to a file, RMS adds a record length header that contains the length of the record (excluding the header) in bytes. When your program retrieves a record, this header is not included in the record buffer. While variable-length records usually make more efficient use of storage space than fixed-length records, manipulation of the record length headers generates processor overhead.

15.1.3 Stream Records

VAX BASIC interprets stream records as a continuous sequence, or stream, of bytes. Unlike the fixed- and variable-length formats, stream records do not contain control information such as record counts, segment flags, or other system-supplied boundaries. Stream records are delimited by special characters or character sequences called *terminators*. Note that stream record formats are valid only in sequential files.

RMS defines three types of stream record format:

- STREAM records can be delimited by any special character (usually a carriage return/line-feed pair).
- STREAM_LF records must be delimited by a line-feed character.
- STREAM_CR records must be delimited by a carriage return.

While you can access existing files of any one of these stream record formats, VAX BASIC creates new stream files only in the STREAM format; you can create files of the other two stream record formats by modifying the RMS FAB control structure in a USEROPEN routine. For more information on USEROPEN routines, see Section 15.8.11.

15.2 File Organizations

VAX BASIC provides several types of file organization: terminal-format, sequential, relative, indexed, and virtual. If you do not specify a file organization when creating a file, the default is a terminal-format file (a sequential file with variable-length records). The following sections describe each type of file organization.

15.2.1 Terminal-Format Files

A terminal-format file is a sequential file of variable-length records. Terminal-format files are the default; that is, you create a terminal-format file when you do not specify a file organization when you open a file. You can then use the PRINT, INPUT, INPUT LINE, and LINPUT statements to access a terminal-format file. See Chapters 7 and 8 for more information about terminal-format files.

15.2.2 Sequential Files

A sequential file contains records that are stored in the order they are written. Sequential files can contain records of any valid VAX BASIC record format: fixed-length, variable-length, or stream. You usually read a sequential file from the beginning; therefore, a sequential file is most useful when you access the data sequentially each time you use it. You can also access sequential fixed-length records randomly by specifying a record number if the file resides on disk. In either case, sequential files can reside on both disk and magnetic tape devices, and those stored on disk support shared access.

15.2.3 Relative Files

A relative file contains a series of "cells" that are numbered consecutively from 1 to *n*, where *n* represents the relative record number. Each cell can contain only a single record. For fixed-length records, the length of each cell equals the record length plus 1 byte. For variable-length records, the length of the cell equals the maximum record size plus 3 bytes.

You can access records in a relative file either sequentially or randomly. The relative record number is the *key value* in random access mode; that is, to access a record in a relative file in random access mode, you must know the relative record number of that record. You can add records to a relative file either at the end of the file or into any empty cell.

Relative files are most useful when randomly accessed and when the record can be identified by its cell number (for example, when inventory numbers correspond to cell numbers). Relative files support shared access. You can delete records from relative files, but not sequential files.

15.2.4 Indexed Files

An indexed file contains data records that are sorted in ascending or descending order according to a *primary index key value*. The index key is a record field (or set of fields) that determines the order in which the records are logically accessed. Keys must be variables declared in a MAP statement. Keys can be any one of the following:

- Strings
- WORD integers
- LONG integers
- Quadword integers
- Packed decimal numbers

String keys can also be segmented; the key can be composed of up to eight string variables in a map. Quadword keys must be referenced using a record or group exactly 8 bytes long.

Along with the primary index key value, you can also specify up to 254 alternate keys; RMS creates one index for each key you specify. For each of these keys you can also specify either an ascending or descending collating sequence. Each index is stored as part of the file, and each entry in the index contains a pointer to a record. Therefore, each key you specify corresponds to a sorted list of record pointers.

An indexed file of library books, for example, might be ordered by book title; that is, the title of the book is the primary key for the file. The keys for alternate indexes might include the author's name and the book's Library of Congress number. Neither of these alternate indexes contains the actual records; instead, they contain sorted pointers to the appropriate records.

Indexed files are most useful when randomly accessed or when you want to access the records in more than one way.

15.2.5 Virtual Files

A virtual file is a random access file that stores one or more data records or virtual array elements in each physical 512-byte disk block. You create a virtual file by specifying ORGANIZATION VIRTUAL as part of the OPEN statement. Apart from virtual arrays and compatibility with BASIC-PLUS and BASIC-PLUS-2, you should use sequential fixed-length instead of virtual files, as they provide the same capabilities. See Section 15.5 for more information on accessing the individual records in a disk block.

15.3 Record Access and Record Context

Record access modes determine the order in which your program retrieves or stores records in a file. They determine the *record context*: the *current record* and the *next record* to be processed. When your program successfully executes any record operation, the current record and next record pointers can change. If a record operation is unsuccessful, these pointers do not change.

The four record access modes valid for RMS are as follows:

- Sequential access—valid on any file organization
- Random-by-record number access—valid on sequential fixed and all relative files
- Random-by-key access—valid on indexed files
- Random-by-RFA (Record File Address) access—valid on any RMS file located on disk

With sequential access, the next record is the next logical record in the file. In the case of relative files, the next logical record is the next existing record (deleted or never-written records are skipped). In the case of indexed files, the next logical record is the record with the next ascending or descending value in the current key of reference depending on that key's collating sequence. You can therefore access relative or indexed files sequentially by not specifying a relative record number or key value.

You can also access sequential fixed-length and relative files randomly by record number; that is, you can specify the record number of the record to be retrieved. For relative files, this record number corresponds to the cell number of the desired record.

You can access indexed files randomly by key. The key specification includes a primary or alternate key and its value. VAX BASIC retrieves the record corresponding to that value in the particular key chosen.

You can access disk files of any organization by Record File Address (RFA); this means that you specify an RFA variable whose value uniquely identifies a particular record. The RFA requires six bytes of information. For more information about RFAs, see Section 15.6.10.

15.4 I/O and Record Buffers

An I/O buffer is a storage area in your program that RMS uses to store data for I/O operations. You do not have direct access to I/O buffers; they are controlled entirely by RMS. The I/O buffer holds blocks of data transferred from the device, and its size is always greater than or equal to that of the record buffer. For more information about the amount of storage allocated for I/O buffers, see the *VMS Record Management Services Manual.*

A record buffer is another storage area in your program. You have direct access to and control of the record buffer. When your program reads a record from a file, the information is transferred from the file to the I/O buffer in one large chunk of data, and then the requested record is transferred to the record buffer. When your program writes a record, data is transferred from the record buffer to the I/O buffer, and then to the file either when the I/O buffer is full or when other blocks need to be read in.

You can use MAP statements to create *static* record buffers and associate program variables with areas (fields) of the buffer. Static record buffers are buffers whose size does not change during program execution and whose program variables are always associated with the same fields in the buffer.

You can create *dynamic* record buffers with either a MAP DYNAMIC or a REMAP statement. These statements, when used after a MAP statement, associate or reassociate a particular program variable with a different area (field) of the record buffer. However, the total size of a record buffer does not change during program execution.

NOTE

> If you do not specify a map, you must use MOVE TO and MOVE FROM statements to transfer data back and forth from the record buffer to program variables. However, MOVE statements do not transfer data to or from a file.

15.5 Accessing the Contents of a Record

VAX BASIC provides several different methods for accessing the contents of a record:

- MAP statement
- MAP DYNAMIC and REMAP statements (dynamic mapping)
- MOVE statements
- FIELD statements

The FIELD statement is a declining feature and is not recommended for new program development. DIGITAL recommends that you use either MAP statements, dynamic mapping, or MOVE statements to access record contents.

15.5.1 The MAP Statement

Normally, a record is divided into predetermined fields, the sizes of which are known at compile time. The MAP statement creates the storage area for this record and determines its total size.

Example 1

```
RECORD name_addr
  STRING last_name = 15,    &
         street_name = 30,  &
  INTEGER house_num
END RECORD
MAP (student_buffer) name_addr student_info
```

Example 2

```
MAP (Emp_rec)
    STRING Emp_name = 25,                 &
    LONG Badge,                           &
    STRING Address = 25,                  &
    STRING Department = 4
```

15.5.2 The MAP DYNAMIC and REMAP Statements

There are situations where predetermined fields are not applicable or possible. In these situations, you must perform record defielding in your program at run time. Using the MAP DYNAMIC statement, you can specify the variables in the map whose positions can change at run time. The REMAP statement then specifies the new positions of the variables named in the MAP DYNAMIC statement.

The following example shows how you can use MAP, MAP DYNAMIC, and REMAP to deblock your record fields. The MAP statement allocates a storage area of 2048 bytes and names it *Emp_rec*. The MAP DYNAMIC statement specifies that the variables *Emp_name*, *Badge*, *Address*, and *Department* are all located in *Emp_rec*, and that their positions can be changed at run time with the REMAP statement. The REMAP statement then redefines these variables to their appropriate sizes.

Example

```
MAP (Emp_rec) FILL$ = 2048

MAP DYNAMIC (Emp_rec)                                       &
    STRING Emp_name,                                        &
    LONG Badge,                                             &
    STRING Address,                                         &
    STRING Department

REMAP (Emp_rec) FILL$ = Record_offset,                      &
    Emp_name = 25,                                          &
    Badge,                                                  &
    Address = 25,                                           &
    Department = 4
```

Note that when accessing virtual or sequential files, you can specify a RECORD clause for the GET statement. The following program opens a virtual file with each block containing 512 bytes. However, each block contains 4 logical records that are 128 bytes long. Each of these logical records consists of a 20-character first name field, a 44-character last name field, and a 64-character company name field.

Example

```
DECLARE WORD Record_number
MAP (Virt) STRING FILL = 512
MAP DYNAMIC (Virt) STRING First_name,         &
                  Last_name,                  &
                  Company
OPEN "VIRT.DAT" FOR INPUT AS FILE #5,         &
             VIRTUAL, MAP Virt
Record_number = 1%
```

```
WHEN ERROR IN
  WHILE -1%
     GET #5, RECORD Record_number
     FOR I% = 0% TO 3%
        REMAP (Virt) STRING FILL = (I% * 128%),  &
              First_name = 20,                    &
              Last_name = 44,                     &
              Company = 64
        PRINT First_name, Last_name, Company
     NEXT I%
     Record_number = Record_number + 1%
  NEXT
USE
   IF ERR = 11%
         THEN
            PRINT "Finished"
            CONTINUE 32767
         ELSE EXIT HANDLER
         END IF
END WHEN
END
```

After the first 512-byte block is brought into memory, the FOR...NEXT loop deblocks the data into 128-byte logical records. At each iteration of the FOR...NEXT loop, the REMAP statement uses the loop variable to mask off 128-byte sections of the block.

For more information on the MAP DYNAMIC and REMAP statements, see Chapter 9 and the *VAX BASIC Reference Manual*.

15.5.3 The MOVE Statement

The MOVE statement defines data fields and moves them to and from the record buffer created by VAX BASIC. For example:

```
MOVE FROM #9%, A$, Cost, Name$ = 30%, ID_num%
```

This statement moves a record with four data fields from the record buffer to the variables in the list:

- A string field *A$* with a default length of 16 characters
- A number field *Cost* of the default data type
- A second 30-character string field *Name$*
- An integer field *ID_num%*

Valid variables in the MOVE list are as follows:

- Scalar variables
- Arrays

- Array elements
- FILL items

Because VAX BASIC dynamically assigns space for string variables, the default string length during a MOVE TO operation is the length of the string. The default for MOVE FROM is 16 characters. An entire array specified in a MOVE statement must include the array name, followed by $n - 1$ commas, where n is the number of dimensions in the array. Note that these commas must be enclosed in parentheses. You specify a single array element by naming the array and the subscripts of that element. The following statement moves three arrays from the program to the record buffer. *A$* specifies a 1-dimensional string array, *C* specifies a 2-dimensional array of the default data type, and *D%* specifies a 3-dimensional integer array. *B*(3,2) specifies the element of array *B* that appears in row 3, column 2.

```
MOVE TO #5%, A$(), C(,), D%(,,), B(3,2)
```

Successive MOVE statements to or from the buffer start at the beginning of the record buffer. If a MOVE TO operation only partially fills the buffer, the rest of the buffer is unchanged. You use the GET statement to read a record from a file, and then you move the data from the buffer to variables and reference the variables in your program. A MOVE TO operation moves data from the variables into the buffer created by VAX BASIC. A PUT or UPDATE statement then moves the data from the buffer to the file.

The following program opens file MOV.DAT, reads the first record into the buffer, and moves the data from the buffer into the variables specified in the MOVE FROM statement.

Example

```
DECLARE STRING Emp_name, Address, Department
DECLARE LONG Badge

OPEN "MOV.DAT" AS FILE #1%,          &
     RELATIVE VARIABLE,              &
     ACCESS MODIFY, ALLOW NONE,      &
     RECORDSIZE 512%
GET #1%
MOVE FROM #1%,                       &
     Emp_name = 25,                  &
     Badge,                          &
     Address = 25,                   &
     Department = 4

    .
    .
    .
```

```
MOVE TO #1%,                             &
     Emp_name = 25,                      &
     Badge,                              &
     Address = 25,                       &
     Department = 4

UPDATE #1%
CLOSE #1%
END
```

The MOVE TO statement moves the data from the named variables into the buffer. The UPDATE statement writes the record back into file MOV.DAT. The CLOSE statement closes the file.

15.6 File and Record Operations

You can perform a variety of operations on files and on the records within a file. The following is a list of all the file and record operations supported by VAX BASIC:

- Open a file for processing with the OPEN statement
- Locate a record in a file with the FIND statement
- Read a record from a file with the GET statement
- Write a record to a file with the PUT statement
- Delete a record from a file with the DELETE statement
- Change the contents of a record field with the UPDATE statement
- Unlock the last record accessed with the UNLOCK statement
- Unlock all previously locked records with the FREE statement
- Write data to a terminal-format file with the PRINT # statement
- Reset the current record pointer to the beginning of a file with the RESTORE # and RESET # statements
- Delete all the records after a certain point; that is, truncate the records, with the SCRATCH statement
- Rename a file with the NAME AS statement
- Close an open file with the CLOSE statement
- Delete an entire file with the KILL statement

Note that before you can perform any operations on the records in a file, you must first open the file for processing.

15.6.1 Opening Files

The OPEN statement opens a file for processing, specifies the characteristics of the file to RMS, and verifies the result. Opening a file with the specification FOR INPUT specifies that you want to use an existing file. Opening a file with the specification FOR OUTPUT indicates that you want to create a new file. If you do not specify FOR INPUT or FOR OUTPUT, VAX BASIC tries to open an existing file. If no such file exists, VAX BASIC then creates a new file.

Clauses to the OPEN statement allow you to specify the characteristics of a file. All OPEN statement clauses concerning file or record format are optional when you open an existing file; those attributes that are not specified default to the attributes of the existing file. When you open an existing file, you must specify the file name, channel number, and unless the file is a terminal-format file, an organization clause. If you do not know the organization of the file you want to open, you can specify ORGANIZATION UNDEFINED. If you specify ORGANIZATION UNDEFINED, also specify RECORDTYPE ANY.

If you do not specify a map in the OPEN statement, the size of your program's record buffer is determined by the OPEN statement RECORDSIZE clause, or by the record size associated with the file. If you specify both a MAP clause and a RECORDSIZE clause in the OPEN statement, the specified record size overrides the size specified by the MAP clause.

The following statement opens a new sequential file of stream format records:

```
OPEN "TEST.DAT" FOR OUTPUT AS FILE #1%,          &
      SEQUENTIAL STREAM
```

The following example creates a relative file and associates it with a static record buffer. The MAP statement defines the record buffer's total size and the data types of its variables. When the program is compiled, VAX BASIC allocates space in the record buffer for one integer, one 16-byte string, and one double-precision, floating-point number. The record size is the total of these fields, or 28 bytes. All subsequent record operations use this static buffer for I/O to the file.

Example

```
MAP (Inv_item) LONG Part_number,                              &
           STRING Inv_name = 16,                              &
           DOUBLE Unit_price
OPEN "INVENTORY.DAT" FOR OUTPUT AS FILE #1%                   &
           ,ORGANIZATION RELATIVE FIXED, ACCESS MODIFY        &
           ,ALLOW READ, MAP Inv_item
```

The following OPEN statement opens a sequential file for reading only (ACCESS READ). Because the OPEN statement does not contain a MAP clause, VAX BASIC creates a record buffer. This record buffer is 100 bytes long.

```
OPEN "CASE.DAT" AS FILE #1%                          &
          ,ORGANIZATION SEQUENTIAL VARIABLE          &
          ,ACCESS READ                               &
          ,RECORDSIZE 100%
```

When you do not specify a MAP statement, your program must use MOVE TO and MOVE FROM statements to move data between the record buffer and a list of variables.

The OPEN statement for indexed files must have a MAP clause. Moreover, if you are creating an indexed file, a PRIMARY KEY clause is required. You can create a segmented index key containing more than one string variable by separating the variables with commas and enclosing them in parentheses. All the string variables must be part of the associated map. In the following example, the primary key is made up of three string variables. This key causes the records to be sorted in alphabetical order according to the person's last name, first name, and middle initial.

```
MAP (Segkey) STRING First_name = 15, MI = 1, Last_name = 15
OPEN "NAMES.IND" FOR OUTPUT AS FILE #1%,                      &
       ORGANIZATION INDEXED,                                  &
       PRIMARY KEY (Last_name, First_name, MI),               &
       MAP Segkey
```

Note that there are restrictions on the maximum record size allowed for various file and record formats. See the *VMS Record Management Services Manual* for more information.

You can use logical names to assign a mnemonic name to all or part of a complete file specification, including node, device, and directory. The advantage in using logical names is that programs do not depend on literal file specifications. You can define logical names:

- From DCL command level with the ASSIGN or DEFINE command
- From within a program with the SYS$CRELMN system service

- From within the BASIC environment with the VAX BASIC command ASSIGN

VAX BASIC supports any valid logical name as part of a file specification.

A logical name specifies a 1- through 255-character name to be associated with the specified device or file specification. If the logical name specifies a device, you must end the logical name with a colon. The following example defines a logical name for a file specification:

```
$ ASSIGN DUA1:[SENDER]PAYROL.DAT PAYROLL_DATA
```

This example defines a logical name for a physical device:

```
$ ASSIGN DUA2: DISK2:
```

Once you define the logical name, you can reference that name in your program.

Example

```
OPEN "PAYROLL_DATA" FOR INPUT AS FILE #1%,  &
        ORGANIZATION SEQUENTIAL
OPEN "DISK2:[SORT_DATA] SORT.LIS" FOR OUTPUT AS FILE #2%, &
        SEQUENTIAL VARIABLE
```

These OPEN statements do not depend on the availability of DUA1: or DUA2: in order to work. If these devices are not available, you can simply redefine the logical names so that they specify other disk drives before running the program. In addition, you can redirect the entire file specification for *PAYROLL_DATA* to point to the test or production version of the data.

For more information on logical names, see the *Introduction to VMS*.

15.6.2 Creating Virtual Array Files

VAX BASIC virtual arrays let you define arrays that reside on disk. You use them just as you would an ordinary array. You create a virtual array by dimensioning an array with the DIM # statement, then opening a VIRTUAL file on that channel. You access virtual arrays just as you do normal arrays. The following DIM # statement dimensions a virtual array on channel #1. The OPEN statement opens a virtual file that contains the array. The last program line assigns a value to one array element.

Example

```
DIM #1%, LONG Int_array(10,10,10)
    .
    .
    .
OPEN "VIRT.DAT" FOR OUTPUT AS FILE #1%, VIRTUAL
    .
    .
    .
Int_array(5,5,5) = 100%
```

Note that you cannot redimension virtual arrays with an executable DIM statement. See Chapter 8 for more information on virtual arrays.

15.6.3 Locating Records

The FIND statement locates a specified record and makes it the current record. Using the FIND statement to locate records can be faster than using a GET statement because the FIND statement does not transfer any data to the record buffer; therefore, it executes faster than a GET statement. However, if you are interested in the contents of a record, you must retrieve it with a GET operation.

The FIND statement sets the current record pointer to the record just found, making it the target for a GET, UPDATE, or DELETE statement. (Note that you must have write access to a record before issuing a PUT, UPDATE, or DELETE operation.) A sequential FIND operation searches records in the following order:

- Sequential files from beginning to end
- Relative files in ascending relative record or cell number order
- Indexed files in ascending or descending order, based on the current key of reference and the key's collating sequence

For sequential fixed-length and relative files, you can find a particular record by specifying a RECORD clause. This is called a random access FIND. You can also perform a random access FIND for indexed files by specifying a key of reference, a relational test, and a key value. In the following example, the first FIND statement finds the first record whose key value either equals or follows SMITH in the key's collating sequence. The second FIND statement finds the first record whose key value follows JONES in the key's collating sequence. Each record found by the FIND statement becomes the current record. (Note that you can only have one current record at a time.)

Example

```
MAP (Emp) STRING Emp_name, LONG Emp_number, SSN
OPEN "EMP.DAT" AS FILE #1%, INDEXED,                &
         ACCESS READ,                               &
         MAP Emp,                                   &
         PRIMARY KEY Emp_name
FIND #1%, KEY #0% NXEQ "SMITH"
FIND #1%, KEY #0% NX "JONES"
```

The string expression can contain fewer characters than the key of the record you want to find. However, if you want to locate a record whose string key field *exactly* matches the string expression you provide, you must pad the string expression with spaces to the exact length of the key of reference. For example:

```
FIND #5%, KEY #0% EQ "TOM      "
FIND #5%, KEY #0% EQ "TOM"
```

The first FIND statement locates a record whose primary key field equals "TOM   ". The second FIND statement locates the first record whose primary key field begins with "TOM".

Table 15–1 displays the status of the current record and next record pointers after both a sequential and a random access FIND.

Table 15–1: Record Context After a FIND Operation

Record Access Mode	File Type	Current Record	Next Record
Sequential FIND	Sequential	Record found	Current record + 1
	Relative	Record found	Next existing record
	Indexed	Record found	Next record in current key order
Random access FIND	All	Record found	Unchanged

Note that a random access FIND operation locates the specified record and makes it the current record, but the next record pointer does not change.

You can specify an ALLOW clause to the FIND statement if you have opened the file with ACCESS MODIFY or ACCESS WRITE and have specified UNLOCK EXPLICIT. The ALLOW clause lets you control the type of lock that RMS puts on the records you access. ALLOW NONE specifies that no other users can access this record (this is the default). ALLOW READ lets other users read the record; however, they cannot perform UPDATE or DELETE operations to this record. ALLOW MODIFY specifies that other users can both read and write to this record. This means that other access

streams can perform GET, DELETE, or UPDATE operations to the specified record.

You can also specify a WAIT clause to the FIND statement; this clause allows you to wait for a record to become available in the event that it is currently locked by another process. In addition, you can specify a REGARDLESS clause; this clause allows you to read a locked record. For more information on the WAIT and REGARDLESS clauses, see Section 15.6.9.

15.6.4 Reading Records

The GET statement moves a record from a file to a record buffer and makes the data available for processing. GET statements are valid on sequential, relative, and indexed files. You should not use GET statements on terminal-format files or virtual array files.

For sequential files, a sequential GET retrieves the next record in the file. For relative files, a sequential GET retrieves the next existing record. For indexed files, a sequential GET retrieves the record with the next ascending or descending value in the current key of reference, depending on that key's collating sequence.

Table 15–2 shows the current record and next record pointers after a GET operation. Note that the values of these pointers vary, depending on whether or not the previous operation was a FIND.

Table 15–2: Record Context After a GET Operation

Record Access Mode	File Type	Current Record	Next Record
Sequential GET with FIND	Sequential	Record found	Current record + 1
	Relative	Record found	Next existing record
	Indexed	Record found	Next record in current key
Sequential GET without FIND	Sequential	Next record	Next record + 1
	Relative	Next existing record	Next existing record + 1

(continued on next page)

Table 15–2 (Cont.): Record Context After a GET Operation

Record Access Mode	File Type	Current Record	Next Record
	Indexed	Next record in current key	Record following next record in current key
Random GET	All	Record specified	Next record in succession

If you precede a sequential GET operation with a FIND operation, the current record is the one located by FIND. If you do not perform a FIND operation before a sequential GET operation, the current record is the next sequential record.

The following example illustrates the use of the GET operation to sequentially access records in an indexed file. The example opens an indexed file and displays the first 25 records with serial numbers greater than AB2721 in ascending primary key value order.

Example

```
MAP (Bec) STRING Owner = 30%, LONG Vehicle_number,     &
          STRING Serial_number = 22%
OPEN "VEH.IDN" FOR INPUT AS FILE #2%,                  &
      ORGANIZATION INDEXED, PRIMARY KEY Serial_number, &
      MAP Bec, ACCESS READ
GET #2%, KEY #0% EQ "AB2721"
FOR I% = 1% TO 25%
      GET #2%
      PRINT "Vehicle Number = ";Vehicle_number
      PRINT "Owner is: ";Owner
      PRINT
NEXT I%
```

The following example performs random GET operations by specifying a record number.

Example

```
MAP (Bec) STRING Owner = 30%, LONG Vehicle_number,    &
          STRING Serial_number = 22%
OPEN "VEH.IDN" FOR INPUT AS FILE #2%,                 &
      ORGANIZATION SEQUENTIAL FIXED,                  &
      MAP Bec, ACCESS READ
INPUT "Which record do you want";A%
```

```
WHILE (A% <> 0%)
   GET #2%, RECORD A%
   PRINT "The vehicle number is", Vehicle_number
   PRINT "The serial number is", Serial_number
   PRINT "The owner of vehicle";Vehicle_number; "is", Owner
   INPUT "Next Record";A%
NEXT
CLOSE #2%
END
```

You can specify an ALLOW clause in a GET statement if you have opened the file with ACCESS MODIFY or ACCESS WRITE and UNLOCK EXPLICIT. The ALLOW clause lets you control the type of lock RMS places on the retrieved record. ALLOW NONE specifies that no other users can access this record (this is the default). ALLOW READ lets other access streams have read access to the record. That is, other users can retrieve the record, but cannot perform DELETE, PUT, or UPDATE operations on it. ALLOW MODIFY lets other access streams perform GET, DELETE, or UPDATE operations on the record.

If you are trying to access a locked record, VAX BASIC signals "Record/bucket locked" (ERR=154). However, if you only need to read this record, you can override the lock with the REGARDLESS clause. The REGARDLESS clause allows you to read a locked record. Use caution when using the REGARDLESS clause because a record accessed in this way may be in the process of being changed by another program.

Alternatively, you can also specify the WAIT clause on a GET statement; the WAIT clause allows you to handle record locked conditions by waiting for the record to become available. Note that if a WAIT clause is specified on a GET operation to a unit-record device such as a terminal, the integer expression indicates how long to wait for the I/O to complete, rather than how long to wait on a record locked condition. For more information, see Section 15.6.9.

15.6.5 Writing Records

For a file opened with ACCESS WRITE or ACCESS MODIFY, the PUT statement moves data from the record buffer to a file using the I/O buffer. PUT statements are valid on RMS sequential, relative, and indexed files. You cannot use PUT statements on terminal-format files or virtual array files.

Sequential access is valid on RMS sequential, relative, and indexed files. For sequential, variable, and stream files, a sequential PUT operation adds a record at the end of the file. For sequential fixed and relative files, PUT writes records sequentially or randomly depending on the presence of a RECORD clause. For indexed files, RMS stores records in order of the

primary key's collating sequence. Therefore, you do not need to specify a random or sequential PUT. Table 15–3 shows the record context after both random and sequential PUT operations.

Table 15–3: Record Context After a PUT Operation

Record Access Mode	File Type	Current Record	Next Record
Sequential PUT	Sequential	None	End of file
Sequential PUT	Relative	None	Next record
Sequential PUT	Indexed	None	Undefined
Random PUT	Relative	None	Unchanged

After a PUT operation, the current record pointer has no value. However, the value of the next record pointer changes depending on the file type and the record access mode used with the PUT operation. In a sequential, stream, or variable file, records can only be added at the end of the file; therefore, the next record after PUT is the end of the file. In a relative, sequential, or fixed file, the next record after a PUT operation is the next logical record.

The following example opens a sequential file with ACCESS APPEND specified. For sequential files, this is almost identical to ACCESS WRITE. The only difference is that, with ACCESS APPEND, VAX BASIC positions the file pointer after the last record in the file when it opens the file for processing. All subsequent PUT operations append the new record to the end of the existing file.

Example

```
MAP (Buff) STRING Code = 4%, Exp_date = 9%, Type_desig = 32%
OPEN "INV.DAT"FOR INPUT AS FILE #2%,                    &
      ORGANIZATION SEQUENTIAL FIXED, ACCESS APPEND,    &
      MAP Buff
WHILE -1%
      INPUT "What is the specification code";Code
      INPUT "What is the expiration date";Exp_date
      INPUT "What is the designator";Type_desig
      PUT #2%
NEXT
```

If the current record pointer is not at the end of the file when you attempt a sequential PUT operation to a sequential file, VAX BASIC signals "Not at end of file" (ERR=149).

In the following example, the PUT statement writes records to an existing indexed file. In this case, the error message "Duplicate key detected" (ERR=134) indicates that a record with a matching key field already exists, and you did not allow duplicates on that key.

Example

```
10      MAP (Purchase_rec) STRING R_num = 5,                    &
                                 Dept_name = 10,                &
                                 Pur_dat = 9
20      OPEN "INFO.DAT"FOR OUTPUT AS FILE #2,                     &
                ORGANIZATION INDEXED FIXED, ACCESS WRITE,       &
                PRIMARY KEY R_num, MAP Purchase_rec
30      WHILE -1%
                INPUT "Requisition number";R_num
                INPUT "Department name";Dept_name
                INPUT "Date of purchase";Pur_dat
                PRINT
                PUT #2%
        NEXT
```

Output

```
Requisition number? 2522A
Department name? COSMETICS
Date of purchase? 15-JUNE-1985

Requisition number? 2678D
Department name? AUTOMOTIVE
Date of purchase? 15-JUNE-1985

Requisition number? 4167C
Department name? AUTOMOTIVE
Date of purchase? 6-JANUARY-1985

Requisition number? 2522A
Department name? SPORTING GOODS
Date of purchase? 25-FEBRUARY-1985

%BAS-F-DUPKEYDET, Duplicate key detected
-BAS-I-ON_CHAFIL, on channel 2 for file USER$$DISK:[MAGNUS]INFO.DAT;8 at
user PC 0017E593
-BAS-O-FROLINMOD, from line 30 in module DUPLICATES
-RMS-F-DUP, duplicate key detected (DUP not set)
```

15.6.6 Deleting Records

The DELETE statement removes a record from a file that was opened with ACCESS MODIFY. After you have deleted a record you cannot retrieve it. DELETE works with relative and indexed files only.

A successful FIND or GET operation must precede the DELETE operation. These operations make the target record available for deletion. In the following example, the FIND statement locates record 67 in a relative file and the DELETE statement removes this record from the file. Because the cell itself is not deleted, you can use the PUT statement to write a record into that cell after deleting its contents.

```
FIND #1%, RECORD 67%
DELETE #1%
```

NOTE

There is no current record after a deletion. The next record pointer is unchanged.

15.6.7 Updating Records

UPDATE writes a new record at the location indicated by the current record pointer. UPDATE is valid on RMS sequential, relative, and indexed files.

The UPDATE statement operates on the current record, provided that you have write access to that record. In order to successfully update a variable-length record, you must know the exact size of the record you want to update. VAX BASIC has access to this information after a successful GET operation. If you have not performed a successful GET operation on the variable-length record, then you must specify a COUNT clause in the UPDATE statement that contains the record size information.

If you are updating a variable length record, and the record that you want to write out is of different size than the record you retrieved, you must use a COUNT clause.

An UPDATE will fail with the exception "No current record" (ERR=131) if you have not previously established a current record with a successful GET or FIND. Therefore, when updating records you should include error trapping in your program to make sure all GET operations execute successfully.

An UPDATE operation on a sequential file is valid only when:

- The file containing the record is on disk
- The new record is the same size as the one it is replacing
- You have established a current record through a GET or FIND operation. Note that COUNT defaults to the size of the current record if a GET was performed. If a FIND operation was used to locate the current record, then you must supply a COUNT value.

The following program searches to find a record in which the *L_name* field matches the specified *Search_name$*. Once this record is found and retrieved, the *Rm_num* field of that record is updated; the program then prompts for another *Search_name$*. If a match is not found, VAX BASIC prints the message "No such record" and prompts the user for another *Search_name$*. The program ends when the user enters a null string for the *Search_name$* value.

Example

```
20      MAP (AAA) STRING L_name = 60%, F_name = 20%, Rm_num = 8%
30      OPEN "STU.DAT"FOR INPUT AS FILE #9%,            &
                ORGANIZATION SEQUENTIAL FIXED, MAP AAA
50      INPUT "Last name";Search_name$
55      Search_name$ = EDIT$(Search_name$, -1%)
60      IF Search_name$ = ""
                THEN GOTO 32010
        END IF
65      RESTORE #9%
70      WHEN ERROR IN
75         GET #9% WHILE Search_name$ <> L_name
        USE
           IF ERR=11
               THEN
                   PRINT "No such record"
                   CONTINUE 50
               ELSE
                   EXIT HANDLER
           END IF
        END WHEN
80      INPUT "Room number";Rm_num
90      UPDATE #9%
100     GOTO 50
32010   CLOSE #9%
32030   PRINT "Update complete"
32767   END
```

NOTE

An UPDATE operation invalidates the value of the current record pointer. The next record pointer is unchanged.

When you update a record in a relative variable file, the new record can be larger or smaller than the record it replaces, provided that it is smaller than the maximum record size set for the file. When you update a record in an indexed variable file, the new record can also be larger or smaller than the record it replaces. The updated record:

- Can be no longer than the maximum record size, if specified
- Must include at least the primary key field

The following program updates a specified record on an indexed file.

Example

```
MAP (UPD) STRING Enrdat = 8%, LONG Part_num, Sh_num, REAL Cost
OPEN "REC.ING"FOR INPUT AS FILE #8%,                          &
      INDEXED, MAP UPD, PRIMARY KEY Part_num
INPUT "Part number to update";A%
Loop1:
WHILE -1%
   GET #8%, KEY #0%, EQ A%
   INPUT "Revised Cost is";Cost
   UPDATE #8%
   INPUT "Next Record";A%
   IF A% = 0%
   THEN
        EXIT Loop1
   END IF
NEXT
CLOSE #8%
END
```

If the new record either omits one of the old record's alternate key fields or changes one of them, the OPEN statement must specify a CHANGES clause for that key field when the file is created. Otherwise, VAX BASIC signals the error "Key not changeable" (ERR=130).

15.6.8 Controlling Record Access

When you open a file, VAX BASIC allows you to specify how you will access the file and what types of access you will allow other running programs while you have the file open.

If you open a file for read access only (ACCESS READ), VAX BASIC by default allows other programs to have unrestricted access to the file. You can restrict access with an ALLOW clause only if the file's security constraints allow you write access to the file.

VAX BASIC by default prevents access by other programs to any file you open with ACCESS WRITE, ACCESS MODIFY, or ACCESS SCRATCH (sequential files only). This default action is equivalent to specifying the OPEN statement ALLOW NONE clause. To allow less restrictive access to the open file, specify ALLOW READ or ALLOW MODIFY.

When a file is open for read access only and you have not restricted access to other programs with ALLOW NONE, VAX BASIC allows other programs to read any record in the file including records that your program is concurrently accessing. However, when you retrieve a record with the GET statement from a file you have opened with the intent to modify, VAX BASIC normally restricts other programs from accessing that record. This restriction is called locking.

To allow other programs to access a record you have locked, you must release the lock on the record in one of the following ways:

- Retrieve another record on the same channel. Unless you have opened the file with the UNLOCK EXPLICIT clause (see the following discussion), this action will unlock the previous record.
- Explicitly unlock the record with the UNLOCK or FREE statement. The UNLOCK statement releases the current record. The FREE statement releases all records locked on a given channel.
- Perform an UPDATE operation on the record. An UPDATE statement causes the current record to be unlocked.
- Close the file.

In addition to the capability of restricting access through the OPEN statement ALLOW clause, VAX BASIC allows programs to explicitly control record locking on each record that is retrieved. To use explicit record locking on a file, the OPEN statement must include an UNLOCK EXPLICIT clause. You may then optionally specify an ALLOW clause on the GET and FIND statements. The ALLOW clause on a GET or FIND statement specifies the type of access allowed by other programs to the record while you are accessing it. For instance, the following statement specifies that other programs may read but not modify the records you have locked:

```
GET #1, ALLOW READ
```

If you specify UNLOCK EXPLICIT when opening a file, all records that you retrieve remain locked until you explicitly unlock them with a FREE, UNLOCK, or CLOSE statement.

15.6.9 Gaining Access to Locked Records

If you are trying to access a record that is currently locked, one possible solution is to use the REGARDLESS clause on the GET or FIND statement. The REGARDLESS clause is useful when you are interested in having only read access to the specified record. Be aware, however, that using the REGARDLESS clause to read a locked record can lead to unexpected results because the record you read can be in the process of being changed by another program.

Another solution is to include a WAIT clause on the GET or FIND statement. Note that you cannot specify a WAIT clause and a REGARDLESS clause on the same statement line. By specifying the WAIT clause, you can tell RMS to wait for a locked record to become available. You can optionally specify an integer expression from 0 through 255 with the WAIT clause. This integer

expression indicates the number of seconds RMS should wait for a locked record to become available. If the record does not become available within the specified number of seconds, RMS signals the error "Keyboard wait exhausted" (ERR=15).

If you do not specify an integer expression with the WAIT clause, RMS waits indefinitely for the record to become available. Once the record becomes available, RMS delivers the record to the program.

Note that a deadlock condition can occur when you cause RMS to wait indefinitely for a locked record. A deadlock condition occurs when two users simultaneously try to access locked records in each other's possession. When a deadlock occurs, RMS signals the error, "RMS$_DEADLOCK". In turn, VAX BASIC signals the error, "Detected deadlock error while waiting for GET or FIND" (ERR=193). To handle this error, you can either stop trying to access the particular record, or, if you must access the record, free all locked records (regardless of the channel) and then attempt the GET or FIND again. You need to unlock all records because you cannot know which record the other process wants.

NOTE

> If the timeout value specified in the WAIT clause is less than the SYSGEN parameter DEADLOCK_WAIT, then a "Keyboard wait exhausted" (ERR=15) message can indicate that either the record did not become available during the specified time, or there is an actual deadlock situation. However, if the timeout value is greater than the SYSGEN parameter DEADLOCK_WAIT, the system correctly specifies that a deadlock situation has occurred.

The following example uses the WAIT clause to overcome a record locked condition and traps the resulting error condition.

Example

```
MAP (worker) STRING first_name = 10,    &
                    last_name = 20,     &
                    badge_number = 6,   &
             LONG   dept_number

MAP (departments) STRING dept_name = 10,  &
                  LONG   dept_code
OPEN "Employee_data.dat" FOR INPUT AS FILE #1%,   &
      INDEXED FIXED, MAP worker, ACCESS MODIFY,   &
      PRIMARY badge_number

OPEN "departments.dat" FOR INPUT AS FILE #2,          &
     INDEXED FIXED, MAP departments, ACCESS MODIFY,   &
     PRIMARY dept_code
```

```
WHEN ERROR IN
   WHILE -1%
     GET #1, WAIT
     WHEN ERROR USE time_expired_handler
       GET #2%, KEY #0 EQ dept_number,  &
           WAIT 10%
     END WHEN
     PRINT badge_number, dept_name
   NEXT
USE
  SELECT ERR
    CASE = 11%
       PRINT "End of file reached"
       CLOSE 1%, 2%
    CASE = 193%
       PRINT "Deadlock detected"
       UNLOCK #2%
       RETRY
    CASE ELSE
       EXIT HANDLER
  END SELECT
END WHEN


HANDLER time_expired_handler
  IF ERR = 15% OR ERR = 193%
    THEN
       PRINT "Department info not available for:"
       PRINT "Employee ";badge_number
       PRINT "Going on to next record."
       CONTINUE
    ELSE
       EXIT HANDLER
  END IF
END HANDLER
END PROGRAM
```

The first WHEN ERROR block traps any deadlock conditions. The WHEN ERROR handler unlocks the current record on channel #2 in case another program is trying to access it and then retries the operation. The detached handler for the second WHEN ERROR block traps timeout errors and deadlock errors. If the desired information does not become available in the specified amount of time, or a deadlock condition occurs, the employee's badge number is printed out with an appropriate message, and the GET statement tries to retrieve the next record in the sequence.

15.6.10 Accessing Records by Record File Address

A Record File Address (RFA) uniquely specifies a record in a file. Accessing records by RFA is therefore more efficient and faster than other forms of random record access.

Because an RFA requires six bytes of storage, VAX BASIC has a special data type, RFA, that denotes variables that contain RFA information. Variables of data type RFA can be used only with the I/O statements and functions that use RFA information, and in comparison and assignment statements. You cannot print these variables or use them in any arithmetic operation. However, you can compare RFA variables using the equal to (=) and not equal to (<>) relational operators.

You cannot create named constants of the RFA data type. However, you can assign values from one RFA variable to another, and you can use RFA variables as parameters.

Accessing a record by RFA requires three steps:

1. Explicitly declare the variable or array of data type RFA to hold the address.
2. Assign the address to the variable or array element. You can do this either with the GETRFA function, or by reading a file of RFAs generated by previous GETRFA functions or by the VMS Sort Utility.
3. Specify the variable in the RFA clause of a GET or FIND statement.

The GETRFA function returns the RFA of the last record accessed on a channel. Therefore, you must access a record in the file with a GET, FIND, or PUT statement before using the GETRFA function. Otherwise, GETRFA returns a zero, which is an invalid RFA. The following example declares an array of type RFA containing 100 elements. After each PUT operation, the RFA of the record is assigned to an element of the array. Once the RFA information is assigned to a program variable or array element, you can use the RFA clause on a GET or FIND statement to retrieve the record.

Example

```
DECLARE RFA R_array(1 TO 100)
DECLARE LONG I
MAP (XYZ) STRING A = 80
OPEN "TEST.DAT" FOR OUTPUT AS FILE #1,      &
      SEQUENTIAL, MAP XYZ
FOR I = 1% TO 100%
    .
    .
    .
    PUT #1
    R_array(I) = GETRFA(1%)
NEXT I
```

You can use the RFA clause on GET or FIND statements for any file organization; the only restriction is that the file must reside on a disk that is accessible to the node that is executing the program. An RFA value is only valid for the life of a specific version of a file. If a new version of a file is created, the RFA values may change. If you attempt to access a record with an invalid RFA value, VAX BASIC signals a run-time error.

The following example continues the previous one. It randomly retrieves the records in a sequential file by using RFAs stored in the array.

Example

```
DECLARE RFA R_array(1% TO 100%)
DECLARE LONG I
MAP (XYZ) STRING A = 80
OPEN "TEST.DAT" FOR OUTPUT AS FILE #1,      &
      SEQUENTIAL, MAP XYZ
FOR I = 1% TO 100%
    .
    .
    .
    PUT #1
    R_array(I) = GETRFA(1%)
NEXT I
WHILE -1%
    PRINT "Which record would you like to see";
    INPUT "(type a carriage return to exit)";Rec_num%
    EXIT PROGRAM IF Rec_num% = 0%
    GET #1, RFA R_array(Rec_num%)
    PRINT A
NEXT
```

15.6.11 Transferring Data to Terminal-Format Files

The PRINT # statement transfers program data to a terminal-format file. In the following example, the INPUT statements prompt the user for three values: *S_name$*, *Area$*, and *Quantity%*. Once these values are entered, the PRINT # statement writes these values to a terminal-format file that is open on channel #4.

Example

```
FOR I% = 1% TO 10%
    INPUT "Name of salesperson":S_name$
    INPUT "Sales district";Area$
    INPUT "Quantity sold";Quantity%
    PRINT #4%, S_name$, Area$, Quantity%
NEXT I%
```

If you do not specify an output list in the PRINT # statement, a blank line is written to the terminal-format file. A PRINT statement without a channel number transfers program data to a terminal. See Chapter 7 for more information.

15.6.12 Resetting the File Position

The RESTORE # statement resets the current record pointer to the beginning of the file; it does not change the file. RESET # is a synonym for RESTORE. For example:

```
RESTORE #3%, KEY #2%
RESET #3%
```

The RESTORE # statement restores the file in terms of the second alternate key. The RESET # statement restores the file in terms of the primary key.

The RESTORE # statement can be used by all RMS file organizations. RESTORE without a channel number resets the data pointer for READ and DATA statements but does not affect any files.

15.6.13 Truncating Files

The SCRATCH statement is valid only on sequential files. Although you cannot delete individual records from a sequential file, you can delete all records starting with the current record through to the end of the file. In order to do this, you must first specify ACCESS SCRATCH when you open the file.

To truncate the file, locate the first record to be deleted. Once the current record pointer points to this record, execute the SCRATCH statement. The following program locates the thirty-third record and truncates the file beginning with that record.

Example

```
OPEN "MMM.DAT" AS FILE #2%,            &
      SEQUENTIAL FIXED, ACCESS SCRATCH

first_bad_record = 33%

FIND #2%, RECORD first_bad_record
SCRATCH #2%
CLOSE #2%
END
```

SCRATCH does not change the physical size of the file; it reduces the amount of information contained in the file. (You can use the DCL command SET FILE/TRUNCATE to truncate the excess file space.) Therefore, you can write records with the PUT statement immediately after a SCRATCH operation.

15.6.14 Renaming Files

If the security constraints permit, you can change the name or directory of a file with the NAME...AS statement. For example:

```
NAME "MONEY.DAT" AS "ACCOUNTS.DAT"
```

This statement changes the name of the file MONEY.DAT to ACCOUNTS.DAT.

NOTE

The NAME...AS statement can change only the name and directory of a file; it cannot be used to change the device name.

You must always include an output file type because there is no default. If you use the NAME...AS statement on an open file, the new name does not take effect until you close the file.

15.6.15 Closing Files and Ending I/O

All programs should close files before the program terminates. However, VAX BASIC automatically closes files in the following situations:

- At an END, END PROGRAM, or EXIT PROGRAM statement
- When it completes the last statement in the program if no END statement exists
- While executing a CHAIN statement

VAX BASIC does not close files after executing a STOP, END SUB, END FUNCTION, or END PICTURE statement.

The CLOSE statement closes files and disassociates these files and their buffers from the channel numbers. If the file is a magnetic tape device and the data is written to a tape, CLOSE writes trailer labels at the end of the file. The following is an example of the CLOSE statement.

Example

```
CLOSE #1%
B% = 4%
CLOSE #2%, B%, 7%
CLOSE I% FOR I% = 1% TO 20%
```

15.6.16 Deleting Files

If the security constraints permit, you can delete a file with the KILL statement. For example:

```
KILL "TEST.DAT"
```

This statement deletes the file named TEST.DAT. Note that this statement deletes only the most current version of the file. Do not omit the file type, because there is no default. You can delete only one file at a time; to delete all versions of a file matching a file specification, use the Run-Time Library routine LIB$DELETE_FILE.

You can delete a file that is currently being accessed by other users; however, the file is not deleted until all users have closed it. You cannot open or access a file once you have deleted it.

15.7 File-Related Functions

VAX BASIC provides built-in functions for finding:

- The characteristics of the last file opened (FSP$)
- The number of bytes moved in the last I/O operation (RECOUNT)
- The file status (STATUS, VMSSTATUS, and RMSSTATUS)

These functions are discussed in the following sections.

15.7.1 The FSP$ Function

If you do not know the organization of a file, you can find out by opening the file for input with the ORGANIZATION UNDEFINED and RECORDTYPE ANY clauses. Your program can then use the FSP$ function to determine the characteristics of that file. Your program must execute FSP$ immediately after the OPEN FOR INPUT statement.

Example

```
RECORD FSP_data
       VARIANT
       CASE
          BYTE Rat
          BYTE Org
          WORD Max_record_size
          LONG File_size
          WORD Bucketsize_blocksize
          WORD Num_keys
          LONG Max_record_number
       CASE
          Ret_string = 16
END RECORD

DECLARE FSP_data File_chars

OPEN "FIL.DAT" FOR INPUT AS FILE #1%,                    &
    ORGANIZATION UNDEFINED,                              &
    RECORDTYPE ANY, ACCESS READ
File_chars::Ret_string = FSP$(1%)
```

- *Rat* returns the low byte that is the RMS record attributes (RAT) field.
- *Org* returns the high byte that is the RMS organization (ORG) field.
- *Max_record_size* returns the RMS maximum record size (MRS) field.
- *File_size* returns the RMS allocation quantity (ALQ) field.
- *Bucketsize_blocksize* returns the RMS bucket size (BKS) field for disk files or the RMS block size (BLS) field for magnetic tape files.
- *Num_keys* returns the number of keys.
- *Max_record_number* returns the RMS maximum record number (MRN) field if the file is a relative file.

Note that FSP$ returns zeros in bytes 9 through 12. For more information, see the *VMS Record Management Services Manual.*

15.7.2 The RECOUNT Function

Read operations can transfer varying amounts of data. The system variable RECOUNT contains the number of characters (bytes) read after each read operation.

After a read operation from your terminal, RECOUNT contains the number of characters transferred, including the line terminator. After accessing a record, RECOUNT contains the number of characters in the record.

RECOUNT is reset by every read operation on any channel, including the controlling terminal. Therefore, if you need to use the value of RECOUNT, copy it to another variable before executing another read operation. RECOUNT is undefined if an error occurs during a read operation.

RECOUNT is often used as the argument to the COUNT clause in the UPDATE or PUT statement for variable-length files. The following sequence of statements ensures that the output record on channel #5 is the same length as the input record on channel #4.

Example

```
GET #4%
bytes_read% =  RECOUNT
   .
   .
   .
PUT #5%, COUNT bytes_read%
```

15.7.3 The STATUS, VMSSTATUS, and RMSSTATUS Functions

The STATUS function accesses the status longword that contains characteristics of the last opened file. If an error occurs during an input operation, the value of STATUS is undefined. If an error does not occur, the six low-order bits of the returned value contain information about the type of device accessed by the last input operation. These bits correspond to the following devices:

- If bit 0 is set, the device type is a record-oriented device.
- If bit 1 is set, the device type is a carriage control device.
- If bit 2 is set, the device type is a terminal.
- If bit 3 is set, the device type is a directory oriented device.
- If bit 4 is set, the device type is a single directory device.
- If bit 5 is set, the device type is a sequential block-oriented device (magnetic tape or TK50).

Both the VMSSTATUS and RMSSTATUS functions are used to determine which non-BASIC error caused a resulting VAX BASIC error. In particular, VMSSTATUS can be used for any non-BASIC errors, while RMSSTATUS is used specifically for RMS errors. For more information on these functions, see Chapter 17 and the *VAX BASIC Reference Manual*.

15.8 OPEN Statement Options

This section explains the OPEN statement keywords that enable you to control how a file is created or opened. These keywords are as follows:

BUCKETSIZE
BUFFER
CONNECT
CONTIGUOUS
DEFAULTNAME
EXTENDSIZE
FILESIZE
NOSPAN
RECORDTYPE
TEMPORARY
USEROPEN
WINDOWSIZE

15.8.1 The BUCKETSIZE Clause

The BUCKETSIZE clause applies only to relative and indexed files. A *bucket* is a logical storage structure that RMS uses to build and maintain relative and indexed files on disk devices. A bucket consists of 1 or more disk blocks. The default bucket size is the record size rounded up to a block boundary. Although RMS defines the bucket size in terms of disk blocks, the BUCKETSIZE clause specifies the number of records a bucket contains. For example:

```
OPEN  "STOCK_DATA.DAT" FOR OUTPUT AS FILE #1%,          &
      ORGANIZATION RELATIVE FIXED, BUCKETSIZE 12%
```

This example specifies a bucket containing approximately 12 records. RMS reads in entire buckets into the I/O buffer at once, and a GET statement transfers one record from the I/O buffer to your program's record buffer.

When you open an existing relative or indexed file and specify a bucket size other than that originally assigned to the file, VAX BASIC signals "File attributes not matched" (ERR=160).

Records cannot span bucket boundaries. Therefore, when you specify a bucket size in your program, you must consider the size of the largest record in the file. Note that a bucket must contain at least one record. Buckets in both relative and indexed files contain information in addition to the records stored in the bucket. You should take this into consideration.

There are two ways to establish the number of blocks in a bucket. The first is to use the VAX BASIC default. The second is to specify the approximate number of records you want in each bucket. VAX BASIC then calculates a bucket size based on that number.

The default bucket size assigned to relative and indexed files is as small as possible. A small bucket size, however, is rarely desirable.

VAX BASIC selects a default bucket size depending on:

- The record length
- The file organization (relative or indexed)
- The record format

If you do not define the BUCKETSIZE clause in the OPEN statement, VAX BASIC does the following:

- Assumes that there is a minimum of one record in the bucket
- Calculates a size
- Assigns the appropriate number of blocks

Note that when you specify a bucket size for files in your program, you must keep in mind the space versus speed tradeoffs. A large bucket size increases file processing speed because a greater amount of data is available in memory at one time. However, it also increases the memory space needed for buffer allocation and the processing time required to search the bucket. Conversely, a small bucket size minimizes buffer requirements, but increases the number of accesses to the storage device, thereby decreasing the speed of operations.

DIGITAL recommends that you use the DCL command EDIT/FDL to design files used in production applications where performance is a concern.

15.8.2 The BUFFER Clause

The BUFFER clause applies to disk files of any organization. In the case of sequential files, the BUFFER clause sets the number of blocks read in on each disk access. For relative and indexed files, the BUFFER clause determines the number of I/O buffers that are allocated. In general, the VMS operating system supplies adequate defaults for all file types; therefore, the BUFFER clause is rarely necessary.

You can specify up to 127 buffers as either a positive or a negative number:

- If (0 < BUFFER < 127), RMS allocates enough space for the specified number of buckets.
- If (–128 < BUFFER < 0), VAX BASIC allocates the absolute value of the specified number of buffers.
- If (BUFFER=0), VAX BASIC allocates the process default for the particular file organization and device—this value is usually adequate.

15.8.3 The CONNECT Clause

The CONNECT clause can be used only on indexed files. CONNECT lets you process different groups of records on different indexed keys or on the same key without incurring all of the RMS overhead of opening the same file more than once. For example, a program can read records in an indexed file sequentially by one key and randomly by another. Each stream is an independent, active series of record operations.

Example

```
MAP (Indmap) WORD Emp_num,                                  &
     STRING Emp_last_name = 20,                             &
     SINGLE Salary,                                         &
     STRING Wage_code = 2
OPEN "IND.DAT" FOR INPUT AS FILE #1%,                       &
     ORGANIZATION INDEXED,                                  &
     MAP Indmap,                                            &
     PRIMARY KEY Emp_num,                                   &
     ALTERNATE KEY Emp_last_name
   .
   .
   .
OPEN "IND.DAT" FOR INPUT AS FILE #2%                        &
     ORGANIZATION INDEXED,                                  &
     MAP Indmap,                                            &
     CONNECT 1
   .
   .
   .
OPEN "IND.DAT" FOR INPUT AS FILE #3%                        &
     ORGANIZATION INDEXED,                                  &
     MAP Indmap,                                            &
     PRIMARY KEY Emp_num,                                   &
     ALTERNATE KEY Wage_code,                               &
     CONNECT 1
```

The channel on which you open the file for the first time is called the *parent*. The CONNECT clause specifies another channel on which you access the same file; connected channels are called *children*. More than one OPEN statement can connect to the parent channel; however, you cannot connect to a channel that has already been connected to another channel. Do not use the CONNECT clause when accessing files on remote DECnet nodes.

15.8.4 The CONTIGUOUS Clause

A contiguous file with physically adjoining blocks minimizes disk searching and decreases file access time. Once the system knows where a contiguous file starts on the disk, it does not need to use as many retrieval pointers to locate the pieces of that file. Rather, it can access data by calculating the distance from the beginning of the file to the desired data. If there is not enough contiguous disk space, VAX BASIC allocates as much contiguous space as possible. (For truly contiguous records, you must use the USEROPEN clause and set the CTG bit in the FAB FOP field—see the *VMS Record Management Services Manual*.)

Opening a file with both the FILESIZE and CONTIGUOUS clauses preextends the file contiguously or in as few disk extents as possible.

15.8.5 The DEFAULTNAME Clause

The DEFAULTNAME clause in the OPEN statement lets you specify a default file specification for the file to be opened. It is valid with all file organizations. VAX BASIC uses the DEFAULTNAME clause for any part of the file specification that is not explicitly supplied.

Example

```
LINPUT "Next data file";Fil$
OPEN Fil$ FOR INPUT AS FILE #5%,        &
     ORGANIZATION SEQUENTIAL,           &
     DEFAULTNAME "USER$DEVICE:.DAT"
```

The DEFAULTNAME clause supplies default values for the device, directory, and file type portions of the file specification. Typing ABC in response to the "Next data file?" prompt causes VAX BASIC to try to open USER$DEVICE:ABC.DAT.

VAX BASIC uses the DEFAULTNAME values only if you do not supply those parts of the file specification appearing in the DEFAULTNAME clause. For example, if you type SYS$DEVICE:ABC in response to the prompt, VAX BASIC tries to open SYS$DEVICE:ABC.DAT. In this case, SYS$DEVICE:

overrides the device default in the DEFAULTNAME clause. Any part of the file specification still missing is filled in from the current default device and directory of the process.

15.8.6 The EXTENDSIZE Clause

The EXTENDSIZE attribute determines how many disk blocks RMS adds to the file when the current allocation is exhausted. The EXTENDSIZE clause only has an effect when creating a file. You specify EXTENDSIZE as a number of blocks. For example:

```
OPEN "TSK.ORN" FOR OUTPUT AS FILE #2%,    &
      ORGANIZATION RELATIVE, EXTENDSIZE 128%
```

The EXTENDSIZE clause causes RMS to add 128 disk blocks whenever the current space allocation is exhausted and the file must be extended.

The value you specify must conform to the following requirements:

- It must be specified when you create the file
- It cannot exceed 65,535 disk blocks

If you specify zero, the extension size equals the RMS default value. The EXTENDSIZE value can be overridden for single OPEN operations.

15.8.7 The FILESIZE Clause

With the FILESIZE attribute, you can allocate disk space for a file when you create it. The following statement allocates 50 blocks of disk space for the file "VALUES.DAT":

```
OPEN "VALUES.DAT" FOR OUTPUT AS FILE #3%, FILESIZE 50%
```

Preextending a file has several advantages:

- The system can create a complete directory structure for the file, instead of allocating and mapping additional disk blocks when needed.
- You reserve the needed disk space for your application. This ensures that you do not run out of space when the program is running.
- Preextension can make some of the file's disk blocks contiguous, especially when used with the CONTIGUOUS keyword.

Note that preextension can be a disadvantage if it allocates disk space needed by other users. The FILESIZE clause is ignored when VAX BASIC opens an existing file.

15.8.8 The NOSPAN Clause

By default, sequential files allow records to cross or span block boundaries. If records cross block boundaries, RMS packs records into the file end-to-end throughout the file, leaving space for control information and padding.

The NOSPAN clause overrides this default, forcing records to fit into individual blocks (with space provided for control information and padding). When block boundaries restrict records, fixed-length records must be less than 512 bytes, and variable-length records less than 510 bytes. This can waste extra bytes at the end of each block. However, when records span block boundaries, RMS writes records end-to-end without regard for block boundaries. For example, if you specify NOSPAN, only four 120-byte records fit into a disk block. If you do not specify NOSPAN, VAX BASIC begins writing the fifth record in the block, and continues writing that record in the next block. This minimizes wasted disk space and improves the file's capacity, at the minimal expense of increased processing overhead.

15.8.9 The RECORDTYPE Clause

The RECORDTYPE clause lets you specify record formats that are compatible with files created by other language processors. You can choose one of four qualifiers: LIST, FORTRAN, ANY, and NONE. The default for VAX BASIC is LIST, which specifies carriage return format. This is standard for ASCII text files and means that carriage control is performed by RMS when writing the file to a unit-record device.

If your program accesses a file created with a FORTRAN language processor, use the FORTRAN qualifier. In the following example, the FORTRAN qualifier sets the FORTRAN carriage control attribute in the RAT field in the FAB. For more information on the FAB control structure, see Section 15.8.11. The first byte of the record is assumed to be the carriage control information.

```
OPEN "FIL.DAT" FOR INPUT AS FILE #1%,      &
     ORGANIZATION SEQUENTIAL, RECORDTYPE FORTRAN
```

If your program accesses a file created by an unknown language processor or by DCL, use the ANY qualifier; this qualifier causes VAX BASIC to handle any record attribute type. If you create a file with the ANY qualifier, VAX BASIC uses the default of LIST.

```
OPEN "FIL.DAT" FOR INPUT AS FILE #1%,       &
     ORGANIZATION INDEXED, RECORDTYPE ANY
```

15.8.10 The TEMPORARY Clause

If you specify the TEMPORARY clause in the OPEN statement, VAX BASIC deletes that file in any one of the following cases:

- When you close the file
- When the program aborts or exits
- When your process terminates

No entry for this file is made in any directory.

15.8.11 The USEROPEN Clause

The USEROPEN clause specifies an external long function that VAX BASIC executes when you open or create a file. (You do not need to declare the USEROPEN routine with an EXTERNAL FUNCTION statement.) This procedure can then specify additional OPEN parameters for the file. For example:

```
OPEN "FILE.DAT" FOR INPUT AS FILE #2%,       &
     ORGANIZATION INDEXED, USEROPEN Myopen, MAP ABC
```

The code in *Myopen* determines how the file FILE.DAT is opened. The Run-Time Library sets up six RMS control structures before calling the USEROPEN procedure. Table 15–4 defines these structures and their meanings.

Table 15–4: VAX RMS Control Structures Set for the USEROPEN Clause

FAB	File Access Block
RAB	Record Access Block
NAM	Name Block
XAB	FHC Extended Attributes Block
ESA	Expanded Name String
RSA	Resultant Name String

A USEROPEN procedure should not alter the allocation of these structures, although it can modify the contents of many of the fields. You should not modify fields set by other OPEN statement keywords. For example, you should use the RECORDSIZE clause, not a USEROPEN routine, to set the record length.

The allocation of the RMS control structures (except for the RAB) lasts only for the duration of the OPEN statement. Therefore, your USEROPEN can retain only the RAB address for use after the OPEN operation is complete. Note that any additional structures that you allocate and link into the RMS structures must be unlinked before exiting the USEROPEN.

NOTE

Future releases of the Run-Time Library may alter the use of some VAX RMS fields. Therefore, you may have to alter your USEROPEN procedures accordingly.

The following steps describe the execution of the USEROPEN routine:

1. VAX BASIC performs normal OPEN statement processing up to the point where it would call the RMS OPEN/CREATE and CONNECT routines. VAX BASIC then passes control to the USEROPEN routine.
2. VAX BASIC passes the address of the FAB as the first parameter, the address of the RAB as the second parameter, and the address of the user-specified channel number as the third parameter to the routine.
3. The USEROPEN routine can modify the contents of the RMS control structures, and it must call the RMS OPEN or RMS CREATE routine and the RMS CONNECT routine and return the status in R0.

The following program creates a USEROPEN routine to obtain a RAB address.

Example

```
%TITLE  "Example USEROPEN"
%SBTTL  "Useropen Routine to obtain RAB address"
%IDENT  "Version 1.0"
```

```
FUNCTION LONG Get_rab_address ( Fabdef User_fab, Rabdef User_rab, LONG Channel )
!++
! FUNCTIONAL DESCRIPTION:
!
!   Save the address of the RMS Record Access Block allocated by the caller
!   in a global symbol.  Open the file and return the status from RMS.
!
! FORMAL PARAMETERS (Standard for all BASIC USEROPEN procedures)
!
!   User_fab    Address of RMS File Access Block
!   User_rab    Address of RMS Record Access Block
!   Channel     Logical Unit assigned to file by caller. !
! RETURN VALUE:    RMS Status value
!
! GLOBAL COMMON USAGE
!
!   RAB_ptr     Single longword PSECT used to pass RAB address to caller.
!
!--
    OPTION  INACTIVE = SETUP,           &
         CONSTANT TYPE = INTEGER,       &
         TYPE = EXPLICIT

    %NOLIST
    %INCLUDE "$FABDEF" %FROM %LIBRARY "SYS$LIBRARY:BASIC$STARLET"
    %INCLUDE "$RABDEF" %FROM %LIBRARY "SYS$LIBRARY:BASIC$STARLET"
    %INCLUDE "$RMSDEF" %FROM %LIBRARY "SYS$LIBRARY:BASIC$STARLET"
    %INCLUDE "STARLET" %FROM %LIBRARY "SYS$LIBRARY:BASIC$STARLET"
    %LIST
    !+
    !   Common area used to pass RAB address to caller.
    !-
    COMMON     (RAB_ptr)    LONG     rab_address

    DECLARE LONG    Rms_status
    !+
    !   Save RAB address in global symbol known to caller.
    !   Perform standard RMS open sequence
    !-
    Rab_address = LOC(User_rab::rab$b_bid)

    Rms_status = Sys$open( User_fab )
    IF Rms_status AND Rms$_normal
    THEN
        Rms_status = Sys$connect( User_rab )
    END IF

END FUNCTION Rms_status
```

NOTE

You cannot use a USEROPEN routine to fill the RBF, UBF, BKS, or CTX fields in the RAB. These fields are filled in after the USEROPEN routine returns; any values placed there by the USEROPEN routine are overwritten. Also, you must not set RMS Locate mode when using a USEROPEN routine on sequential files.

15.8.12 The WINDOWSIZE Clause

The WINDOWSIZE clause specifies the number of block retrieval pointers in memory for the file. WINDOWSIZE is not a file attribute, and therefore can be changed any time you open a file.

Retrieval pointers are associated with the file header and point to contiguous blocks on disk. By keeping retrieval pointers in memory, you can reduce the I/O associated with locating a record because the operating system does not have to access the file header for pointers as frequently. The number of retrieval pointers in memory at any one time is determined by the system default or by the value you supply in the WINDOWSIZE clause. The usual default number of retrieval pointers is 7.

A value of zero specifies the default number of retrieval pointers. A value of –1 specifies mapping the entire file, if possible. Values between –128 through –2 are reserved.

Chapter 16

Formatting Output with the PRINT USING Statement

The PRINT USING statement controls the appearance and location of data on a line of output. With it, you can create formatted lists, tables, reports, and forms. This chapter describes how to format data with the PRINT USING statement.

16.1 Introduction

The ability to format data with the PRINT USING statement is useful because the way in which VAX BASIC displays data with the PRINT statement is often limited. For example, a program may use floating-point numbers to represent dollars and cents. The PRINT statement displays floating-point numbers with up to six digits of accuracy, and places the decimal point anywhere in that 6-digit field. In contrast, PRINT USING lets you display floating-point numbers in the following ways:

- Rounded to two decimal places
- Vertically aligned on the decimal point
- Preceded by a dollar sign
- With commas every third digit to the left of the decimal point

Formatting monetary values in this way provides a much more readable report. Another use for formatted numeric values might be to print checks on a line printer. PRINT USING lets you print numbers with a dollar sign and an asterisk-filled field preceding the first digit.

PRINT USING also formats string data. With it you can left- and right-justify string expressions, or center a string expression over a specified column position. Further, the PRINT USING statement can contain string literals. These are strings that do not control the format of a print item, but instead are printed exactly as they appear in the format string.

DIGITAL recommends that you declare all format expressions as string constants. When you do this the VAX BASIC compiler causes the Run-Time Library to compile the string at compile time rather than at run time, thus improving the performance of your code.

16.2 Using Format Strings

Format strings determine the way in which items are to be printed in the output file. Format strings can be any of the following:

- String variables
- String literals
- Named string constants
- A combination of the previous strings

The PRINT USING statement must contain one or more format strings. Each format string is made up of one *format field*. Each format field controls the output of one print item and can contain only certain characters, as described throughout the chapter.

The PRINT USING statement must also contain a list of items you want printed. To format print items, you must separate them with commas or semicolons. Separators between print items do not affect output format as they do with the PRINT statement. However, if a comma or semicolon follows the last print item, VAX BASIC does not return the cursor or print head to the beginning of the next line after it prints the last item in the list.

When VAX BASIC encounters an invalid character within the current format field, it automatically ends the format field. Therefore, you do not need to delimit format fields. The character that terminates the previous field can be either a new format field or a string literal.

In the following example, the first three characters in the format string (###) make up a valid numeric format field. The fourth character (A) is invalid in a numeric format field; therefore, VAX BASIC ends the first format field after the third character. VAX BASIC continues to scan the format string, searching for a character that begins a format field. The first such character is the number sign at character position 7. Therefore, the characters at positions 4, 5, and 6 are treated as a string literal. The

characters at positions 7, 8, and 9 make up a second valid numeric format field.

Example

```
PRINT USING "###ABC###", 123, 345
```

Output

```
123ABC345
```

When the statement executes, VAX BASIC prints the first number in the list using the first format field, then prints the string literal ABC, and finally prints the second number in the list using the second format field. If you were to supply a third number in the list, VAX BASIC would reuse the first format string. This is called *reversion*.

Example

```
PRINT USING "###ABC###", 123, 345,
564
```

Output

```
123ABC345
564ABC
```

Because any character not part of a format field is printed just as it appears in the format field, you can use a space or multiple spaces to separate format fields in the format string as shown in the following example.

Example

```
DECLARE STRING CONSTANT format_string = "###.##   ###.##"
DECLARE SINGLE A,B
A = 2.565
B = 100.350
PRINT USING format_string, A, B, A, B
```

Output

```
  2.57   100.35
  2.57   100.35
```

When the VAX BASIC compiler encounters the PRINT USING statement, VAX BASIC prints the value of *A* (rounded according to PRINT USING rules), three spaces, then the value of *B*. VAX BASIC prints the three spaces because they are treated as a string literal in the format string. Notice that when VAX BASIC reuses a format string, it begins on a new line.

16.3 Printing Numbers

With the PRINT USING statement, you can specify:

- The number of digits to print, thus rounding the number to a given place
- The decimal point location, thus vertically aligning numbers at the decimal point
- Special symbols, including trailing minus signs, asterisk-filled number fields, floating currency symbols, embedded commas, and E notation
- Debits and credits
- Leading zeros or leading spaces
- Blank-if-zero fields
- A special character that is to be printed as a literal

Unlike the PRINT statement, PRINT USING does not automatically print a space before and after a number. Unless you reserve enough digit positions to contain the integer portion of the number (and a minus sign, if necessary), VAX BASIC prints a percent sign (%) to signal this condition and displays the number in PRINT format.

16.3.1 Specifying the Number of Digits

You reserve places for digits by including a number sign (#) for each digit position. If you print negative numbers, you must also reserve a place for the minus sign.

Example

```
PRINT USING "###",123        !Three places reserved
PRINT USING "#####",12345   !Five places reserved
PRINT USING "####",-678     !Four places reserved
END
```

Output

```
123
12345
-678
```

If there are not enough digits to fill the field, VAX BASIC prints spaces before the first digit.

Example

```
format_string$ = "#####"
PRINT USING format_string$, 1
PRINT USING format_string$, 10
PRINT USING format_string$, -1709
PRINT USING format_string$, 12345
END
```

Output

```
    1
   10
-1709
12345
```

If you have not reserved enough digits to print the fractional part of a number, VAX BASIC rounds the number to fit the field.

Example

```
PRINT USING "###",126.7
PRINT USING "#",5.9
PRINT USING "#",5.4
END
```

Output

```
127
6
5
```

If you have not reserved enough places to print a number's integer portion, VAX BASIC prints a percent sign as a warning followed by the number in PRINT statement format. After VAX BASIC prints the number, it completes the rest of the list in PRINT USING format.

In the following example, PRINT USING displays the first number. Because there are not enough places to the left of the decimal point to display a 3-digit number, VAX BASIC prints the second number in PRINT statement format, with a space before and after, but includes a percent sign warning.

Example

```
PRINT USING "###", 256
PRINT USING "##", 256
END
```

Output

```
256
% 256
```

16.3.2 Specifying Decimal Point Location

The decimal point's position in the format string determines the number of reserved places on either side of it. If the print item's fractional part does not use all of the reserved places to the right of the decimal point, VAX BASIC fills the remaining spaces with zeros.

Example

```
DECLARE STRING CONSTANT FM = "##.###"
PRINT USING FM, 15.72
PRINT USING FM, 39.3758
PRINT USING FM, 26
```

Output

```
15.720
39.376
26.000
```

If there are more fractional digits than reserved places to the right of the decimal point, VAX BASIC rounds the number to fit the reserved places. Note that there must be enough places reserved to the left of the decimal point for the integer portion of the number. Otherwise, VAX BASIC prints the number in PRINT format preceded by a percent sign. The following example shows how PRINT USING rounds numbers when you specify decimal point location.

Example

```
PRINT USING "##.##", 25.789
PRINT USING "##.###", 100.2
PRINT USING "#.##",.999
END
```

Output

```
25.79
% 100.2
1.00
```

VAX BASIC fills all reserved spaces to the left of the decimal point with specified digits, spaces, or the minus sign.

Example

```
PRINT USING "##.##", 5.25
PRINT USING "##.##", -5.25
PRINT USING "###.##,-5.25
END
```

Output

```
 5.25
-5.25
 -5.25
```

16.3.3 Printing Numbers with Special Symbols

Special symbols let you print numbers with trailing minus signs, asterisk-fill fields, floating currency symbols, commas, or E notation. You can also specify debits, credits, leading zeros, leading blanks, and blank-if-zero fields. Table 16–1 summarizes these special characters.

Table 16–1: Format Characters for Numeric Fields

Character	Effect on Format
Number sign (#)	Reserves a place for one digit.
Decimal point (period)(.)	Determines decimal point location and reserves a place for the radix point.
Comma (,)	Prints a comma before every third digit to the left of the decimal point and reserves a place for one digit or digit separator.
Two asterisks (**)	Print leading asterisks before the first digit and reserve places for two digits.
Two dollar signs ($$)	Print a currency symbol before the first digit. They also reserve places for the currency symbol and one digit. By default, the currency symbol is a dollar sign. To change the currency symbol, see Section 16.3.3.3
Four carets (^^^^)	Print a number in E (exponential) format and reserve four places for E notation.

(continued on next page)

Table 16–1 (Cont.): Format Characters for Numeric Fields

Character	Effect on Format
Minus sign (–)	Prints a trailing minus sign for negative numbers. Printing a negative number in an asterisk-fill or a currency field requires that the field also have a trailing minus sign or credit/debit character.
Zero in angle brackets (<0>)	Prints leading zeros instead of leading spaces.
Percent sign in angle brackets (<%>)	Prints all spaces in the field if the value of the print item, when rounded to fit the numeric field, is zero.
CD in angle brackets (<CD>)	Prints credit and debit characters immediately following the number. VAX BASIC prints CR for negative numbers and zero, and DR for positive numbers.
Underscore (_)	Specifies that the next character is a literal, not a formatting character.

16.3.3.1 Commas

You can place a comma anywhere in a number field to the left of the decimal point or to the right of the field's first character. A comma cannot start a format field. VAX BASIC prints a comma to the left of every third digit from the decimal point. If there are fewer than four digits to the left of the decimal point, VAX BASIC omits the comma.

Example

```
PRINT USING "##,###",10000
PRINT USING "##,###",759
PRINT USING "$$#,###.##",25694.3
PRINT USING "**#,###",7259
PRINT USING "####,#.##",25239
END
```

Output

```
 10,000
    759
 $25,694.30
 **7,259
 25,239.00
```

16.3.3.2 Asterisk Fill Fields

To print asterisks (*) before the first digit of a number, you must start the field with two asterisks.

Example

```
DECLARE STRING CONSTANT FM = "**##.##"
PRINT USING FM, 1.2
PRINT USING FM, 27.95
PRINT USING FM, 107
PRINT USING FM, 1007.5
END
```

Output

```
***1.20
**27.95
*107.00
1007.50
```

Note that the asterisks reserve two places as well as cause asterisk fill.

To specify a negative number in an asterisk-fill field, you must place a trailing minus sign in the field. The trailing minus sign must be the last character in the format string.

Example

```
DECLARE STRING CONSTANT FM = "**##.##-"
PRINT USING FM, 27.95
PRINT USING FM, -107
PRINT USING FM, -1007.5
END
```

Output

```
**27.95
*107.00-
1007.50-
```

If you try to print a negative number in an asterisk-fill field that does not include a trailing minus sign, VAX BASIC signals "PRINT USING format error" (ERR=116).

You cannot specify both asterisk-fill and zero-fill for the same numeric field.

16.3.3.3 Currency Symbols

To print a currency symbol before the first digit of a number, you must start the field with two dollar signs. If the data contains both positive and negative numbers, you must include a trailing minus sign.

Example

```
DECLARE STRING CONSTANT FM = "$$##.##-"
PRINT USING FM, 77.44
PRINT USING FM, 304.55
PRINT USING FM, 2211.42
PRINT USING FM, -125.6
PRINT USING FM, 127.82
END
```

Output

```
 $77.44
$304.55
% 2211.42
$125.60-
$127.82
```

Note that the dollar signs reserve places for the currency symbol and only one digit; the dollar sign is always printed. (Hence the warning indicator (%) when the third PRINT USING statement executes.) Contrast this with the asterisk-fill field, where VAX BASIC prints asterisks only when there are leading spaces.

By default, the currency symbol is a dollar sign. On VMS systems, you can change the currency symbol, radix point, and digit separator by assigning the characters you want to the logical names SYS$CURRENCY, SYS$RADIX_POINT, and SYS$ DIGIT_SEP, respectively.

If you try to print a negative number in a dollar sign field that does not include either a trailing minus sign or the CR/DR formatting character, VAX BASIC signals "PRINT USING Format error" (ERR=116).

16.3.3.4 Negative Fields

To allow for a field containing negative values, you must place a trailing minus sign in the format field. A negative format field causes the value to be printed with a trailing minus sign. You can also denote negative fields with CR and DR. See Section 16.3.3.8 for more information.

You must use a trailing minus or the CR/DR formatting character to indicate a negative number in an asterisk-fill or floating dollar sign field.

For fields with trailing minus signs, VAX BASIC prints a minus sign after negative numbers as shown in Example 1, and a space after positive numbers as shown in Example 2.

Example 1

```
!Standard field
PRINT USING "###.##",-10.54
PRINT USING "###.##",10.54
END
```

Output 1

```
-10.54
 10.54
```

Example 2

```
!Fields with Trailing Minus Signs
PRINT USING "##.##-",-10.54
PRINT USING "##.##-",10.54
END
```

Output 2

```
10.54-
10.54
```

16.3.3.5 E (Exponential) Format

To print a number in E format, you must place four carets (^^^^) at the end of the field. The carets reserve space for:

- The capital letter E
- A plus or minus sign (which indicates a positive or negative exponent)
- An exponent (the exponent is 2 digits for single and double, 3 digits for g_floating, and 4 digits for h_floating)

In exponential format, VAX BASIC does not pad the digits to the left of the decimal point. Instead, the most significant digit shifts to the leftmost place of the format field, and the exponent compensates for this adjustment.

Example

```
PRINT USING "###.##^^^^",5
PRINT USING "###.##^^^^",1000
PRINT USING ".##^^^^",5
END
```

Output

```
 500.00E-02
 100.00E+01
.50E+01
```

If you use fewer than four carets, the number does not print in E format; the carets print as literal characters. If you use more than four carets, VAX BASIC prints the number in E format and includes the extra carets as a string literal.

Example

```
PRINT USING "###.##^^^",5
PRINT USING "###.##^^^^^",5
END
```

Output

```
   5.00^^^
 500.00E-02^
```

You must reserve a place for a minus sign to the left of the decimal point to display negative numbers in exponential format. If you do not, VAX BASIC prints a percent sign (%) as a warning.

You cannot use exponential format with asterisk-fill, floating-dollar sign, or trailing minus formats.

16.3.3.6 Leading Zeros

To print leading zeros in a numeric field, you must start the format field with a zero enclosed in angle brackets (<0>). These characters also reserve one place for a digit.

Example

```
DECLARE STRING CONSTANT FM = "<0>####.##"
PRINT USING FM, 1.23, 12.34, 123.45, 1234.56, 12345.67
```

Output

```
00001.23
00012.34
00123.45
01234.56
12345.67
```

When you specify zero-fill, you cannot specify asterisk-fill or floating-dollar sign format for the same field.

16.3.3.7 Blank-If-Zero Fields

To make VAX BASIC print a blank field for values which round to zero, you must start the numeric field with a percent sign (%) enclosed in angle brackets (<%>).

In the following example, PRINT USING displays spaces in each reserved position for the second and third items in the list. The value of the second item is zero, while the value of the third item becomes zero when rounded to fit the numeric field.

Example

```
DECLARE STRING CONSTANT FM = "<%>####.##"
PRINT USING FM, 1000, 0, .001, -5000
```

Output

```
  1000.00


 -5000
```

16.3.3.8 Debits and Credits

You can have VAX BASIC use credit and debit notation to differentiate positive and negative numbers. To do this, you place the characters <CD> (Credit/Debit) at the end of the numeric format string. This causes VAX BASIC to print CR (Credit Record) after negative numbers, and DR (Debit Record) after positive numbers and zero.

Example

```
DECLARE STRING CONSTANT FM = "$$####.##<cd>"
PRINT USING FM, -552.35, 200, -5
```

Output

```
 $552.35CR
 $200.00DR
   $5.00CR
```

You cannot use a trailing minus sign and Credit/Debit formatting in the same numeric field. Using the Credit/Debit formatting character causes the value to be printed with a leading space.

16.4 Printing Strings

With the PRINT USING statement, you can specify the following aspects of string format:

- The number of characters
- Left-justified format
- Right-justified format
- Centered format
- Extended field format

Table 16–2 summarizes the format characters and their effects.

Table 16–2: Format Characters for String Fields

Character	Effect on Format
Single quotation mark (')	Starts the string field and reserves a place for one character.
L (upper- or lowercase)	Left-justifies the string and reserves a place for one character.
R (upper- or lowercase)	Right-justifies the string and reserves a place for one character.
C (upper- or lowercase)	Centers the string in the field and reserves a place for one character.
E (upper- or lowercase)	Left-justifies the string; expands the field, as necessary, to print the entire string; and reserves a place for one character.

(continued on next page)

Table 16–2 (Cont.): Format Characters for String Fields

Character	Effect on Format
Two backslashes (\ \ )	Reserves n+2 character positions, where n is the number of spaces between the two backslashes. PRINT USING left-justifies the string in this field. This formatting character is included for compatibility with BASIC-PLUS. DIGITAL recommends that you not use this type of field for new program development.
Exclamation point (!)	Creates a 1-character field. The exclamation point both starts and ends the field. This formatting character is included for compatibility with BASIC-PLUS. DIGITAL recommends that you not use this type of field for new program development. Instead, use a single quotation mark to create a 1-character field.

You must start string format fields with a single quotation mark (') that reserves a space in the print field, followed by:

- A contiguous series of upper- or lowercase Ls for left-justified output
- A contiguous series of upper- or lowercase Rs for right-justified output
- A contiguous series of upper- or lowercase Cs for centered output
- A contiguous series of upper- or lowercase Es for extended field output

VAX BASIC ignores the overflow of strings larger than the string format field except for extended fields. For extended fields, VAX BASIC extends the field to print the entire string. If a string to be printed is shorter than the format field, VAX BASIC pads the string field with spaces. For more information on extended fields, see Section 16.4.4.

A string field containing only a single quotation mark is a 1-character string field. VAX BASIC prints the first character of the string expression corresponding to a 1-character string field and ignores all following characters.

Example

```
PRINT USING "'","ABCDE"
END
```

Output

```
A
```

See Section 16.4.4 for an example of many different types of fields used together.

16.4.1 Left-Justified Format

VAX BASIC prints strings in a left-justified field starting with the leftmost character. VAX BASIC pads shorter strings with spaces and truncates longer strings on the right to fit the field.

A left-justified field contains a single quotation mark followed by a series of Ls.

Example

```
PRINT USING "'LLLLLL","ABCDE"
PRINT USING "'LLLL","ABC"
PRINT USING "'LLLLL","12345678"
END
```

Output

```
ABCDE
ABC
123456
```

16.4.2 Right-Justified Format

VAX BASIC prints strings in a right-justified field starting with the rightmost character. VAX BASIC pads the left side of shorter strings with spaces. If a string is longer than the field, VAX BASIC left-justifies and truncates the right side of the string.

A right-justified field contains a single quotation mark (') followed by a series of Rs.

Example

```
DECLARE STRING CONSTANT right_justify = "'RRRRR"
PRINT USING right_justify,"ABCD"
PRINT USING right_justify,"A"
PRINT USING right_justify,"STUVWXYZ"
END
```

Output

```
  ABCD
     A
STUVWX
```

16.4.3 Centered Fields

VAX BASIC prints strings in a centered field by aligning the center of the string with the center of the field. If VAX BASIC cannot exactly center the string—as is the case for a 2-character string in a 5-character field, for example—VAX BASIC prints the string one character off center to the left.

A centered field contains a single quotation mark followed by a series of Cs.

Example

```
DECLARE STRING CONSTANT center = "'CCCC"
PRINT USING center, "A"
PRINT USING center, "AB"
PRINT USING center, "ABC"
PRINT USING center, "ABCD"
PRINT USING center, "ABCDE"
END
```

Output

```
  A
 AB
 ABC
ABCD
ABCDE
```

If there are more characters than places in the field, VAX BASIC left-justifies and truncates the string on the right.

16.4.4 Extended Fields

An extended field contains a single quotation mark followed by one or more Es. The extended field is the only field that automatically prints the entire string. In addition:

- If the string is smaller than the format field, VAX BASIC left-justifies the string as in a left-justified field.
- If the string is longer than the format field, VAX BASIC extends the field and prints the entire string.

Example

```
PRINT USING "'E", "THE QUICK BROWN"
PRINT USING "'EEEEEEE', "FOX"
END
```

Output

```
THE QUICK BROWN
FOX
```

The following example uses left-justified, right justified, centered, and extended fields.

Example

```
PRINT USING "'LLLLLLLLL","THIS TEXT"
PRINT USING "'LLLLLLLLLLLLLL","SHOULD PRINT"
PRINT USING "'LLLLLLLLLLLLLL",'AT LEFT MARGIN'
PRINT USING "'RRRR","1,2,3,4"
PRINT USING "'RRRR",'1,2,3'
PRINT USING "'RRRR',"1,2"
PRINT USING "'RRRR","1"
PRINT USING "'CCCCCCCCC","A"
PRINT USING "'CCCCCCCCC","ABC"
PRINT USING "'CCCCCCCCC","ABCDE"
PRINT USING "'CCCCCCCCC","ABCDEFG"
PRINT USING "'CCCCCCCCC","ABCDEFGHI"
PRINT USING "'LLLLLLLLLLLLLLLLL',"YOU ONLY SEE PART OF THIS"
PRINT USING "'E","YOU CAN SEE ALL OF THE LINE WHEN IT IS EXTENDED"
END
```

Output

```
THIS TEXT
SHOULD PRINT
AT LEFT MARGIN
1,2,3
1,2,3
  1,2
    1
    A
   ABC
  ABCDE
 ABCDEFG
ABCDEFGHI
YOU ONLY SEE PART
YOU CAN SEE ALL OF THE LINE WHEN IT IS EXTENDED
```

16.5 PRINT USING Statement Error Conditions

There are two types of PRINT USING error conditions: fatal and warning. VAX BASIC signals a fatal error if:

- The format string is not a valid string expression
- There are no valid fields in the format string
- You specify a string for a numeric field
- You specify a number for a string field
- You separate the items to be printed with characters other than commas or semicolons
- A format field contains an invalid combination of characters
- You print a negative number in a floating-dollar sign or asterisk-fill field without a trailing minus sign

VAX BASIC issues a warning if a number does not fit in the field. If a number is larger than the field allows, VAX BASIC prints a percent sign (%) followed by the number in the standard PRINT format and continues execution.

If a string is larger than any field other than an extended field, VAX BASIC truncates the string and does not print the excess characters.

If a field contains an invalid combination of characters, VAX BASIC does not recognize the first invalid character or any character to its right as part of the field. These characters may form another valid field or be considered text. If the invalid characters form a new valid field, a fatal error condition may arise if the item to be printed does not match the field.

The following examples demonstrate invalid character combinations in numeric fields.

Example 1

```
PRINT USING "$$**##.##",5.41,16.30
```

The dollar signs form a complete field and the rest forms a second valid field. The first number (5.41) is formatted by the first valid field ($$). It prints as "$5". The second number (16.30) is formatted by the second field (**##.##) and prints as "**16.30".

Output 1

```
$5**16.30
```

Example 2

```
PRINT USING "##.#^^^",5.43E09
```

Because the field has only three carets instead of four, VAX BASIC prints a percent sign and the number, followed by three carets.

Output 2

```
% .543E+10^^^
```

Example 3

```
PRINT USING "'LLEEE","VWXYZ"
```

You cannot combine two letters in one field. VAX BASIC interprets EEE as a string literal.

Output 3

```
VWXEEE.
```

Chapter 17

Handling Run-Time Errors

The process of detecting and correcting errors that occur when your program is running is called *error handling*. This chapter describes default error handling and how to handle VAX BASIC run-time errors with your own *error handlers*.

Throughout this chapter, the term *error* is used to imply any VMS exception, not only an exception of ERROR severity.

17.1 Default Error Handling

VAX BASIC provides default run-time error handling for all programs. If you do not provide your own error handlers, the default error handling procedures remain in effect throughout program execution time.

When an error occurs in your program, VAX BASIC diagnoses the error and displays a message telling you the nature and severity of the error. There are four severity levels of VAX BASIC errors: SEVERE, ERROR, WARNING, and INFORMATIONAL. The severity of an error determines whether or not the program aborts if the error occurs when default error handling is in effect. When default error handling is in effect, ERROR and SEVERE errors always terminate program execution, but program execution continues when WARNING and INFORMATIONAL errors occur.

To override the default error handling procedures, you can provide your own error handlers, as described in the following sections. (Note that you should not call LIB$ESTABLISH from a VAX BASIC program as this RTL routine overrides the default error handling procedures and may adversely affect program behavior.)

Only one error can be handled at a time. If an error has occurred but has not yet been handled completely, that error is said to be *pending*. When an error is pending and a second error occurs, program execution always terminates immediately. Therefore, one of the most important functions of an error handler is to *clear* the error so that subsequent errors can also be handled.

If you do not supply your own error handler, program control passes to the VAX BASIC error handler when an error occurs. For instance, when VAX BASIC default error handling is in effect, a program will abort when division by zero is attempted because division by zero is an error of SEVERE severity. With an error handler, you can include an alternative set of instructions for the program to follow; if the zero was input at a terminal, a user-written error handler could display a "Try again" message and reexecute the program lines requesting input.

17.2 User-Supplied Error Handlers

It is good programming practice to anticipate certain errors and provide your own error handlers for them. User-written error handlers allow you to handle errors for a specified block of program statements as well as complete program units. Any program module can contain one or more error handlers. These error handlers test the error condition and include statements to be executed if an error occurs.

To provide your own error handlers, you use WHEN ERROR constructs. A WHEN ERROR construct consists of two blocks of code: a *protected region* and a *handler*. A protected region is a block of code that is monitored by the compiler for the occurrence of an error. A handler is the block of code that receives program control when an error occurs during the execution of the statements in the protected region.

There are two forms of WHEN ERROR constructs; in both cases the protected region begins immediately after a WHEN ERROR statement. The following partial programs illustrate each form. In Example 1, the handler is attached to the protected region, while in Example 2, the handler *catch_handler* is detached and must be provided elsewhere in the program unit.

Example 1

```
WHEN ERROR IN
     protected_statement_1
     protected_statement_2
     .
     .
     .
 USE
     handler_statement_1
     handler_statement_2
     .
     .
     .
END WHEN
```

Example 2

```
WHEN ERROR USE catch_handler
     protected_statement_1
     protected_statement_2
     .
     .
     .
END WHEN

HANDLER catch_handler
     handler_statement_1
     handler_statement_2
     .
     .
     .
END HANDLER
```

The following sections further explain the concepts of protected regions and handlers.

17.2.1 Protected Regions

A protected region is a block of code that is monitored by the compiler for the occurrence of an error. The bounds of this region are determined by the actual ordering of the source code. Statements that are lexically between a WHEN ERROR statement and a USE or END WHEN statement are in the protected region.

If an error occurs inside the protected region, control passes to the error handler associated with the WHEN ERROR statement. When an error occurs beyond the limits of a protected region, default error handling is in effect unless other error handlers are provided. For more details about handler priorities, see Sections 17.2.3 and 17.3.

The WHEN ERROR statement signals the start of a block of protected statements. The WHEN ERROR statement also specifies the handler to be used for any errors that occur inside the protected region. The keyword USE either explicitly names the associated handler for the protected region, or marks the start of the actual handler statements. The statements in the actual error handler receive control only if an error occurs in the protected region.

The following example prompts the user for two integer values and displays their sum. The WHEN ERROR block traps any invalid input values, displays a message telling the user that the input was invalid, and reprompts the user for input.

```
DECLARE INTEGER value_1, value_2

WHEN ERROR IN
     INPUT "PLEASE INPUT 2 INTEGERS"; value_1, value_2 !protected statement
USE
     PRINT "INVALID INPUT - PLEASE TRY AGAIN" !handler statement
     RETRY                                    !handler statement
END WHEN
PRINT "THEIR SUM IS"; value_1 + value_2
```

Protected regions can be nested; a protected region can be within the bounds of another protected region. However, WHEN ERROR statements cannot appear inside an error handler, and protected regions cannot cross over into other block structures. If you are using a WHEN ERROR block with a detached handler, that handler cannot exist within a protected region.

17.2.2 Handlers

A handler is the block of code containing instructions to be executed only when an error occurs during the execution of statements in the protected region. When an error occurs during the execution of a protected region, VAX BASIC branches to the handler you have supplied. In turn, the handler processes the error. An error handler typically performs the following functions:

- Determines which error occurred
- Takes appropriate action based on the nature of the error
- Clears the error condition with a RETRY, CONTINUE, END WHEN, or END HANDLER statement
- Continues program execution when possible
- Possibly identifies which program unit or statement caused the error

- Resignals errors with EXIT HANDLER (when an error cannot be handled for some reason)

Handlers can be attached to, or detached from, the statements in the WHEN ERROR protected region.

An *attached handler* is delimited by a USE and an END WHEN statement. The attached handler immediately follows the protected region of a WHEN ERROR IN block. The following example illustrates an attached handler that traps errors on I/O statements, division by zero, and illegal numbers:

```
PROGRAM accident_prone
 DECLARE REAL age, accidents, rating
 WHEN ERROR IN
 Get_age:
      INPUT "Enter your age";age
      INPUT "How many serious accidents have you had";accidents
      rating = accidents/age
      PRINT "That's ";rating;" serious accidents per year!"
 USE
      SELECT ERR
         !Trap division by zero
         CASE = 61
                  PRINT "Please enter an age greater than 0"
                  CONTINUE Get_age
         !Trap illegal number
         CASE = 52
                  PRINT "Please enter a positive number"
                  RETRY
         CASE ELSE
              !Revert to default error handling
              EXIT HANDLER
      END SELECT
 END WHEN
END PROGRAM
```

A *detached handler* is defined separately in your program unit. It requires an identifier and must be delimited by a HANDLER and an END HANDLER statement. Handler names must be valid VAX BASIC identifiers and cannot be the same as the identifier for any label, PROGRAM name, DEF or DEF* function, SUB, FUNCTION, or PICTURE subprogram. The main advantage of using a detached handler is that it can be referenced by more than one WHEN ERROR USE statement. The following example illustrates a simple detached handler:

```
 WHEN ERROR USE catcher
   KILL "INPUT.DAT"
```

```
END WHEN
   .
   .
   .
HANDLER catcher
  !Catch if file does not exist
  IF ERR = 5
     THEN CONTINUE
  END IF
END HANDLER
```

The statements within a handler are never executed if an error does not occur or if no protected region exists for the statement that caused the exception.

When your program generates an error, control transfers to the specified handler. If the code in an error handler generates a second error, control returns to the VAX BASIC error handler and program execution ends, usually with the first error only partly processed. To avoid the possibility of your error handler causing a second error, you should keep handlers as simple as possible and keep operations that might cause errors outside the handler.

Your handler can include conditional expressions to test the error and branch accordingly, as shown in the following example:

```
PROGRAM Check_records
WHEN ERROR USE Global_handler
    .
    .
    .
END WHEN
HANDLER Global_handler
 SELECT ERR
        !Trap buffer overflow
        CASE = 161
            PRINT "Record too long"
            CONTINUE
        !Trap end of file on device
        CASE = 11
            PRINT "End of file"
            CONTINUE
        CASE ELSE
            EXIT HANDLER
 END SELECT
END HANDLER
CLOSE #1%
END PROGRAM
```

Note that ON ERROR statements are not allowed within protected regions or handlers. For compatibility issues related to ON ERROR statements, see Section 17.3.

17.2.3 Exiting from Handlers

After processing an error, a handler typically clears the error so that program execution can continue. VAX BASIC provides statements that clear the error condition and exit from the handler:

- RETRY
- CONTINUE
- END HANDLER
- END WHEN

These statements differ from each other in that they revert control of program execution to different points in the program. Examples of these statements are included in the following sections.

An additional statement, EXIT HANDLER, is provided to allow you to exit from a handler with the error still pending.

The END HANDLER statement identifies the end of the block of statements in the handler. The END WHEN statement marks the end of the protected region when a detached handler is used; it marks the end of the handler when an attached handler is used. If the handler does not process an error with an EXIT HANDLER, RETRY, or CONTINUE statement, the error is cleared by the END HANDLER or END WHEN statement; however, processing continues with the statement immediately after the protected region (and the attached handler, if one exists) where the error occurred. These statements do not return control to the protected region. This is known as "falling out the bottom of a handler." Be careful not to fall out of the bottom of a handler unintentionally.

Note that you cannot exit from a handler with the following statements:

- EXIT PROGRAM
- EXIT FUNCTION
- EXIT SUB
- EXIT DEF
- GOSUB (with a target outside the handler)
- GOTO (with a target outside the handler)

Also, you cannot exit from a handler with a RESUME statement. The RESUME statement is valid only in blocks of code referred to by ON ERROR statements. Section 17.3 describes the ON ERROR statements.

17.2.3.1 The RETRY Statement

You use the RETRY statement to clear the error and reexecute the statement that caused the error. Be sure to take corrective action before trying the protected statement again.

```
DECLARE REAL radius

WHEN ERROR USE fix_it
     INPUT "Please supply the radius of the circle"; radius
END WHEN
HANDLER fix_it
     !trap overflow error
     IF ERR = 48
     PRINT "Please supply a smaller radius"
     RETRY
END HANDLER
PRINT "The circumference of the circle is "; 2*PI*radius
```

In FOR...NEXT loops, if the error occurs while VAX BASIC is evaluating the limit or increment values, RETRY reexecutes the FOR statement; if the error occurs while VAX BASIC is evaluating the index variable, RETRY reexecutes the NEXT statement. In UNTIL...NEXT and WHILE...NEXT loops, if the error occurs while VAX BASIC is evaluating the relational expression, RETRY reexecutes the NEXT statement.

17.2.3.2 The CONTINUE Statement

You can use the CONTINUE statement to clear the error and cause execution to continue at the statement immediately following the propagated error.

When the CONTINUE statement is within an attached handler, you can specify a target. The target can be a line number or label within the bounds of the associated protected region, in a surrounding protected region, or within an unprotected region. However, you must specify a target within the current program module. You cannot specify a target for the CONTINUE statement when it is in a detached handler.

```
DIM LONG her_attributes(10),his_attributes(10)
DECLARE INTEGER counter
WHEN ERROR USE fix_it
  DATA 12,2,35,21,25.5,32,32,30,15,4
  FOR counter = 0 TO 12
      READ her_attributes(counter)
  NEXT counter
  MAT his_attributes = her_attributes
END WHEN
   .
   .
   .
HANDLER fix_it
    !Trap out of data
    IF ERR = 57
       THEN RESTORE
            CONTINUE
    ELSE EXIT HANDLER
    END IF
END HANDLER
```

When a DEF function is invoked from a protected region and an error occurs that has not been handled, a CONTINUE statement with no target causes execution to resume at the statement following the one that invoked the function.

Note that if an error occurs in a loop control statement or SELECT or CASE statement, the CONTINUE statement causes VAX BASIC to resume execution at the statement following the end of the loop structure (the NEXT, END CASE, or END SELECT statements).

NOTE

> When you use the RETRY or the CONTINUE statement without a target, the compiler builds read only tables in the generated object file with information about statements in the associated protected regions. Therefore, when space is extremely critical, do not protect large regions with handlers containing RETRY or CONTINUE without a specified target.

17.2.3.3 The EXIT HANDLER Statement

Unlike RETRY and CONTINUE, the EXIT HANDLER statement does not clear the error; rather, it allows you to exit from the handler with the error pending. This allows you to pass an error to the handler associated with the next outer protected region, or back to VAX BASIC default error handling, or to the calling procedure.

When an error occurs within a nested protected region, control passes to the handler associated with the innermost protected region in which the error occurred. If the innermost handler does not handle the error, the error is passed to the next outer handler with the EXIT HANDLER statement. All handlers for any outer WHEN ERROR blocks are processed before reverting to default error handling or resignaling the calling procedure.

The following example shows two nested protected regions. Neither handler traps division by zero. If division by zero occurs, the handler associated with the innermost protected region, *inner_handler*, does not clear the error; therefore, the error is passed to the handler associated with the next outer protected region. *Outer_handler* does not clear this error either, and so the error is passed to the default error handler. As this error is fatal, the program aborts.

Example

```
PROGRAM nesting
 OPTION TYPE = EXPLICIT
 DECLARE LONG divisor
 DECLARE REAL dividend, quotient
 WHEN ERROR USE outer_handler
      INPUT "Enter divisor";Divisor
      INPUT "Enter dividend";Dividend

      WHEN ERROR USE inner_handler
           Quotient = Dividend/Divisor
           PRINT "The quotient is ";Quotient
      END WHEN

 END WHEN
 HANDLER outer_handler
         !Trap data format error
         IF ERR = 50
            THEN
            PRINT "Illegal input...try again"
            RETRY
            ELSE PRINT "In outer_handler"
                 PRINT "Reverting to default handling now"
                 EXIT HANDLER
         END IF
 END HANDLER
 HANDLER inner_handler
         !Trap overflow/decimal error
         IF ERR = 181
            THEN CONTINUE
            ELSE PRINT "Inside inner_handler"
                 PRINT "Reverting to outer handler now"
                 EXIT HANDLER
         END IF
 END HANDLER
END PROGRAM
```

Output

```
Enter divisor? 0
Enter dividend? 53
Inside inner_handler
Reverting to outer handler now
Inside outer_handler
Reverting to default handling now
%BAS-F-DIVBY_ZER, Division by 0
-BAS-USEPC_PSL, at user PC=001C18B3, PSL=03C000A4
-SYSTEM-F-FLTDIV_F, arithmetic fault, floating divide by zero at
PC=001C18B3, PSL=03C000A4
-BAS-I-FROLINMOD, in module ERROR_7
```

For more information about exiting program units while an error is pending, see Section 17.2.6.

17.2.4 Selecting the Severity of Errors to Handle

The OPTION HANDLE statement lets you specify the severity level of errors that are to be handled by an error handler in addition to the BASIC errors that can normally be handled or trapped. You can specify any one of the following error severity levels: BASIC, SEVERE, ERROR, WARNING, or INFORMATIONAL.

OPTION HANDLE = BASIC is the default, which is in effect if you do not specify an alternative in the OPTION HANDLE statement. Only trappable VAX BASIC errors transfer control to the current error handler when this option is in effect. Refer to Appendix B to determine which BASIC errors are not trappable.

When you specify an error severity level other than BASIC in the OPTION HANDLE statement, the following errors will transfer control to the error handler:

- All trappable BASIC errors of this or lesser severity
- All non-BASIC errors of this or lesser severity
- BASIC errors of this or lesser severity that are not normally trappable

For example, if you specify OPTION HANDLE = ERROR, you can handle all BASIC and non-BASIC errors of ERROR severity (both trappable and nontrappable), and all WARNING and INFORMATIONAL errors, but no SEVERE errors.

17.2.5 Identifying Errors

VAX BASIC provides several built-in functions that return information about an error. You can use these functions inside your error handlers to determine details about the error and conditionally handle these errors. These functions include:

- ERR
- ERL
- ERN$
- ERT$
- VMSSTATUS
- RMSSTATUS

Note that if an error occurs in your program that is not a VAX BASIC error or does not map onto a VAX BASIC error, it is signaled as NOTBASIC ("Not a BASIC error") (ERR=194). In this case, you can use the built-in function VMSSTATUS to determine what caused the error. VMSSTATUS is discussed in Section 17.2.5.5.

17.2.5.1 Determining the Error Number (ERR)

You use the ERR function to return the number of the last error that occurred. Appendix B in this manual lists the number of each VAX BASIC run-time error. For instance, ERR 153 is "RECALREXI, Record already exists". The following example shows a handler that traps this error:

```
OPTION HANDLE = ERROR
WHEN ERROR USE find_error
    .
    .
    .
END WHEN

HANDLER find_error
  SELECT ERR
        !Record already exists
        CASE = 153
                PRINT "Choose new record"
                CONTINUE
        CASE ELSE
                EXIT HANDLER
  END SELECT
END HANDLER
```

The results of ERR remain undefined until an error occurs. Although ERR remains defined as the number of the last error after control leaves the error handler, it is poor programming practice to refer to this variable outside the scope of an error handler.

17.2.5.2 Determining the Error Line Number (ERL)

After your program generates an error, the ERL function returns the BASIC line number of the signaled error. This function is valid only in line-numbered programs. The ERL function, like ERR, lets you set up branching to one of several paths in the code.

The following handler continues execution at different points in the program, depending on the value of ERL:

```
10 DECLARE INTEGER CONSTANT TRUE = -1
20 WHEN ERROR USE err_handler
   .
   .
   .
900 END WHEN
1000 HANDLER err_handler
       SELECT TRUE
           CASE (ERR = 11) AND (ERL = 790)
               !Is error end of file at line 790?
               PRINT "Completed"
               CONTINUE
           CASE (ERR = 149) AND (ERL = 80)
               !Is error not at end of file on line 80?
               PRINT "CHECK ACCESS MODE"
               CONTINUE
           CASE ELSE
               !Let VAX BASIC handle any other errors
               EXIT HANDLER
1500   END SELECT
2000 END HANDLER
32000   CLOSE #5
32767   END
```

The results of ERL are undefined until an error occurs, or if the error occurs in a subprogram not written in VAX BASIC. Although ERL remains defined as the line number of the last error even after control leaves the error handler, it is poor programming practice to refer to this variable outside the scope of an error handler.

If you reference ERL in a compilation unit with line numbers, code and data are included in your program to allow VAX BASIC to determine ERL when an exception occurs. If you do not need to reference ERL, you can save program size and reduce execution time by compiling your program with the /NOLINE qualifier. Note that if your program references ERL and you compile the program with the /NOLINE switch, VAX BASIC signals the

message "ERL overrides /NOLINE" and the program is compiled with the /LINE qualifier. Even if you do not use any line numbers, you can reduce execution time by compiling with the /NOLINE qualifier.

If an error occurs in a subprogram containing line numbers, VAX BASIC sets the ERL variable to the subprogram line number where the error was detected. If the subprogram also executes an EXIT HANDLER statement, control passes back to the outer procedure's handler. The error is assumed to occur on the statement where the call or invocation occurs.

17.2.5.3 Determining Where the Error Occurred (ERN$)

You use the ERN$ function to return the name of the program unit in which the error was detected. ERN$ returns the name of a main program, SUB, FUNCTION, or PICTURE subprogram, or DEF function. If the PROGRAM statement is used with a user-supplied identifier, the ERN$ value is the specified identifier for the main program. The results of ERN$ are undefined until the program generates an error.

In the following example, control passes to the main program for error handling if the error occurs in the module SUBARC:

```
HANDLER locat_ern
  IF ERN$ = "SUBARC"
     THEN PRINT "ERROR IS ";ERR
          PRINT "RETURNING TO MAIN PROGRAM FOR ERROR HANDLING"
          EXIT HANDLER
     ELSE  PRINT "PROGRAM MODULE GENERATING ERROR IS ";ERN$
  END IF
END HANDLER
```

Note that ERN$ is invalid when an error occurs in a subprogram compiled with the /NOSETUP qualifier.

17.2.5.4 Determining the Error Message Text (ERT$)

You use the ERT$ function to access the message text associated with a specified error number. Use of the ERT$ function is not limited to the scope of the error handler; you can access ERT$ at any time. The following detached handler tests whether the error occurred in a DEF module named TSLFE, and, if so, prints the text of the signaled error and resumes execution:

```
HANDLER catch_it
  IF ERN$ = "TSLFE"
        THEN PRINT ERT$(ERR)
        CONTINUE
        ELSE EXIT HANDLER
  END IF
END HANDLER
```

17.2.5.5 Determining VMS Error Information

VAX BASIC provides a built-in function, VMSSTATUS, that returns the originally signaled error before it is translated to a BASIC error. For instance, for the BASIC error "End of file on device" (ERR=11), the VMSSTATUS function returns "RMS$_EOF" (RMS end of file). This function is useful when the error is NOTBASIC (ERR=194).

When there is no error pending, VMSSTATUS is undefined. The value returned by this function is the actual signaled error value. If non-BASIC errors are being handled, the VMSSTATUS function may be the only way to find out which error caused the exception.

The following example shows a program that performs file I/O. The first WHEN ERROR block traps any errors that occur while the program is opening the file or requesting user input. The detached handler for this block checks the value of VMSSTATUS to determine the exception that occurred. The inner error handler handles two special errors, BAS$K_RECNOTFOU and BAS$K_RECBUCLOC, separately. If the error signaled does not correspond to one of these, the inner error handler passes control to the outer handler with the EXIT HANDLER statement. The outer handler sets the program status to VMSSTATUS. When the program exits, the operating system displays any status that is of warning severity or greater.

```
PROGRAM Tester

 OPTION HANDLE = ERROR
 EXTERNAL LONG CONSTANT BAS$K_RECNOTFOU, BAS$K_RECBUCLOC
 DECLARE LONG Final_status
 MAP (Rec_buffer)                                &
      STRING Rec_key        = 5,                 &
      STRING Rest_of_record = 20
 Final_status = 1
 WHEN ERROR USE Global_handler
      OPEN "My_database" FOR INPUT AS FILE #1   &
           ,INDEXED FIXED                       &
           ,ACCESS READ                         &
           ,MAP Rec_buffer                      &
           ,PRIMARY Rec_key
 Get_key:
     INPUT "Record to retrieve"; Rec_key
```

```
    WHEN ERROR IN
         GET #1%, KEY #0 EQ Rec_key
         PRINT Rest_of_record
    USE
         SELECT ERR
             CASE = BAS$K_RECNOTFOU
                    PRINT "Record not found"
                    CONTINUE Get_key
             CASE = BAS$K_RECBUCLOC
                    SLEEP 2%
                    RETRY
             CASE ELSE
                  EXIT HANDLER
         END SELECT
    END WHEN
   END WHEN
   HANDLER Global_handler
           Final_status = VMSSTATUS
   END HANDLER

END PROGRAM Final_status
```

17.2.5.6 Determining RMS Error Information

The RMSSTATUS function lets you determine which RMS error caused a resulting VAX BASIC error. You must specify an open channel as the first parameter to RMSSTATUS. If this channel is not open, the error "I/O channel not open" (ERR=9) is signaled. The second parameter to the function lets you specify either STATUS or VALUE; this parameter is optional. If you do not specify the second parameter, RMSSTATUS returns the STATUS value by default. STATUS represents the RMS "STS" field and VALUE corresponds to the RMS "STV" field.

The following example shows an error handler that prints both the status and the value of any RMS error:

```
WHEN ERROR IN
     OPEN "file.txt" FOR OUTPUT AS FILE 1%
     PRINT #1%, TIME$(0%)
USE
     !Error 12 is fatal system I/O failure
     IF ERR = 12
        THEN
        PRINT "An unexpected RMS error has occurred:"
        PRINT "Status = "; RMSSTATUS(1%)
        PRINT "Value = "; RMSSTATUS(1%, VALUE)
        EXIT HANDLER
     END IF
END WHEN

CLOSE #1%
GOTO done

done:
    END
```

If you want to find an RMS status without knowing which particular channel to check, you can use VMSSTATUS to get the STATUS value (STS) if an error has occurred.

17.2.6 CTRL/C Trapping

Error handling procedures are commonly used to trap user CTRL/C responses. With CTRL/C trapping enabled, control is transferred to an error handler if a user presses CTRL/C during program execution. You enable CTRL/C trapping in your program by invoking the built-in CTRLC function. For example:

```
Y% = CTRLC
```

After you invoke the CTRLC function, a CTRL/C entered at the terminal transfers control to the error handler. Once the CTRL/C is trapped, you can include routines to interact with the program, as shown in the following example.

Example

```
WHEN ERROR IN
  Y% = CTRLC
  OPEN 'FIL_DAT' FOR INPUT AS FILE #1%
  INPUT "HOW MANY RECORDS"; Rec_read%
  FOR I% = 1% TO Rec_read%
    GET #1%
    PRINT Name$, Address$, Emp_code%
    PRINT
  NEXT I%

USE
  !Trap ^C
  IF (ERR = 28%)
     THEN PRINT "CURRENT RECORD IS "; I%
     ELSE EXIT HANDLER
  END IF
  CONTINUE Clean_up
END WHEN
    .
    .
    .
Clean_up:
  CLOSE #1%
  PRINT "END OF PROCESSING"
END
```

Output

```
SMITH, DEXTER 231 COLUMBUS ST          09341

TRAVIS, JOHN  PO BOX 80                64119

^C

THE CURRENT RECORD IS 3

END PROCESSING
```

Note that the error condition is still pending until the error handler executes the CONTINUE statement. Therefore, if you press CTRL/C a second time while the error handler is executing, control returns to the VAX BASIC error handler, which terminates the program.

To disable CTRL/C trapping, use the RCTRLC function. The RCTRLC function disables only CTRL/C trapping, not the CTRL/C interrupts themselves. Alternatively, to prevent both CTRL/C and CTRL/Y from interrupting a program, use the DCL command SET NO CONTROL, or the RTL routine LIB$DISESTABLISH. See the *VAX BASIC Reference Manual* for more details about the CTRLC and RCTRLC functions.

17.2.7 Handling Errors in Multiple-Unit Programs

You can use WHEN ERROR constructs anywhere in your main program or program modules. Procedure and function invocations, such as invocations of DEF and DEF* functions and SUB, FUNCTION, and PICTURE subroutines, as well as non-BASIC programs, are valid within protected regions. GOTO and GOSUB statements are valid within handlers provided that the target is within the handler, an outer handler, or an unprotected region. Note, however, that a detached handler cannot appear within DEF or DEF* functions without the associated protected region.

When an error occurs within nested handlers, VAX BASIC maintains the same priorities for handler use; control always passes to the handler associated with the innermost protected region in which the error occurred. When an exception occurs, all handlers for any outer WHEN ERROR blocks are processed before the program reverts to default error handling. Outer handlers are invoked when an inner handler executes an EXIT HANDLER statement. When there are no more outer handlers, and the outermost handler executes an EXIT HANDLER statement, program control reverts to the handler associated with the calling routine.

```
SUB LIST(A$)
  WHEN ERROR USE sub_handler
      OPEN A$ FOR INPUT AS FILE #12%
  Get_data:
      LINPUT #12%, B$
      PRINT B$
      GOTO Get_data
  END WHEN
  HANDLER sub_handler
    !Trap end of file
    IF ERR <> 11%
        THEN EXIT HANDLER
    END IF
END HANDLER
CLose_up:
   CLOSE #12%
END SUB
```

You can call a subprogram while an error is pending; however, if you do, the subprogram cannot resignal an error back to the calling program. If the subprogram tries to resignal an error, VAX BASIC signals "Improper error handling" and program execution terminates.

The following rules apply to error handling in function definitions:

- DEF and DEF* function definitions cannot appear within a protected region. However, protected regions can be contained within the function definitions.
- To trap errors while a DEF function is active, include protected regions inside the DEF function. If you do this, the associated handler remains in effect until your program leaves the protected region, or the DEF function.

```
WHEN ERROR IN
.
.
.
Invoke_def:
  A% = FNIN_PUT%("PROMPT")
USE
   PRINT "ERROR"; ERT$(ERR%);
   IF ERN$ = "FNIN_PUT"
      THEN PRINT "IN FUNCTION"
           CONTINUE
      ELSE PRINT "IN MAIN"
           CONTINUE Invoke_def
   END IF
END WHEN
```

```
Main_code:
DEF FNIN_PUT%(P$)
 WHEN ERROR IN
    PRINT P$
    INPUT LINE_IN$
    FNIN_PUT% = INTEGER(LINE_IN$)
USE
     IF ERR = 50
        THEN RETRY
        ELSE EXIT HANDLER
     END IF
END WHEN
END DEF
```

NOTE

If you invoke a GOSUB statement or a DEF* function from within a protected region and the invoked procedure is outside of any protected region, all pending errors are handled by the WHEN ERROR handler unless a previously executed ON ERROR statement specifies otherwise.

17.2.8 Forcing Errors

The CAUSE ERROR statement allows a program to artificially generate an error when the program would not otherwise do so. You can force any VAX BASIC run-time error. You must specify the number of the error the compiler should force; the error numbers are listed in Appendix B of this manual. The following statement forces an end-of-file error (ERR=11) to occur:

```
CAUSE ERROR 11%
```

You can use this feature to debug an error handler during program development, as shown in the following example:

```
WHEN ERROR IN
   .
   .
   .
 CAUSE ERROR 11%
   .
   .
   .
USE
   SELECT ERR
        CASE = 11%
             PRINT "Trapped an end of file on device"
             CONTINUE
        CASE ELSE
             EXIT HANDLER
END WHEN
```

17.3 Using the ON ERROR Statements

VAX BASIC supports ON ERROR statements as an alternative to WHEN blocks primarily for compatibility with existing programs. WHEN ERROR blocks are similar to declarative statements in that they do not depend on run-time flow of control. The ON ERROR statements, however, affect error handling only if the statements execute at run time. For example, if a GOTO statement precedes an ON ERROR statement, the ON ERROR statement will not have any effect because it does not execute.

WHEN ERROR blocks let you handle errors that occur in a specific range of statements. ON ERROR statements let you specify a general error handler that is in effect until you specify another ON ERROR statement or until you pass control to the VAX BASIC error handler.

NOTE

> For all current program development, DIGITAL recommends that you use WHEN ERROR constructs for user-written error handlers. Mixing WHEN ERROR constructs and ON ERROR statements within the same program is not recommended. The ON ERROR statements are supported for compatibility with other versions of BASIC available from DIGITAL. It is important to note that all of these statements are illegal within a protected region, or an attached or detached handler.

The ON ERROR statements are fully documented in the *VAX BASIC Reference Manual*. This section merely illustrates the main features of the ON ERROR statements.

The ON ERROR statements can be used to transfer control to a labeled block of error handling code. If you have executed an ON ERROR statement and an error occurs, the ON ERROR statement immediately transfers control to the label or line number that starts the error handling code. Otherwise, the ON ERROR statement specifies the branch to be taken in the event of an error.

There are three forms of the ON ERROR statement:

- ON ERROR GOTO 0

  The ON ERROR GOTO 0 statement reverts control to VAX BASIC default error handling in one of two ways:

  - If an error is pending, execution of the ON ERROR GOTO 0 statement returns control to the VAX BASIC error handler immediately.

- If no error is pending, an ON ERROR GOTO 0 statement disables your current error handler. The VAX BASIC error handler handles all subsequent errors until another ON ERROR statement is executed, unless an error occurs in a WHEN ERROR protected region.

- ON ERROR GO TO *target*

  The ON ERROR GOTO *target* statement reverts control to the target when subsequent errors occur that are not handled by WHEN block handlers.

- ON ERROR GO BACK

  The ON ERROR GO BACK statement transfers control to the calling program's error handler if an error occurs in the subprogram or DEF function. If you use ON ERROR GO BACK in a PROGRAM unit (outside of a DEF function) and no other outer protected region exists, it is equivalent to ON ERROR GOTO 0 and VAX BASIC default error handling is in effect. With ON ERROR GO BACK, if an error occurs in the execution of a function or subprogram, the error is passed to either the error handler of the surrounding program module (in the case of a DEF function definition) or to the error handler of the calling program (in the case of a separately compiled subprogram).

  An error handler in the DEF function does not permanently override an error handler in the main program. VAX BASIC saves the error handler in the main program when you transfer into a DEF, and restores it when you return.

Traditionally, the ON ERROR GOTO statement is placed before any other executable statements. The following example clears end-of-file errors and passes all other errors back to the VAX BASIC default error handling procedures:

```
5 ON ERROR GOTO Error_handler
   .
   .
   .
Error_handler:
    !Trap end of file on device
    IF ERR = 11
        THEN
                RESUME 1000
        ELSE
                ON ERROR GO BACK
    END IF
```

The ON ERROR GOTO statement remains in effect after your program successfully handles an error. When the system signals another error, control once again transfers to the specified error handler.

Every ON ERROR error handler must end with one of the following statements:

- RESUME [*target*]
- ON ERROR GOTO 0
- ON ERROR GO BACK

If none of these statements is present, the VAX BASIC error handler aborts your program with the fatal error "Error trap needs RESUME" as soon as an END, END SUB, END DEF, END FUNCTION, END PROGRAM, or END PICTURE statement is encountered. The RESUME statement, like the RETRY and CONTINUE statements, clears the error condition.

You can resume execution at any line number or label that is in the same module as the RESUME statement, unless that line or target is inside a DEF function, a WHEN ERROR protected region, or a handler. In general, RESUME without a target transfers control to the beginning of the program block where the error occurred.

- If you resume execution at a multistatement line, execution begins at the first statement after the line number or label—not necessarily at the statement that generated the error.
- If an entire loop block is associated with a single line number or label and an error occurs within the loop, RESUME with no target transfers control to the statement immediately *after* the FOR, WHILE, or UNTIL statement, not to the line number or label.

For more details on the RESUME statement, see the *VAX BASIC Reference Manual*.

DIGITAL does not recommend using both ON ERROR statements and WHEN ERROR constructs in the same program. However, when this is the case, the order of handler priorities is as follows:

1. Control passes to the handler associated with the innermost WHEN ERROR block.
2. If protected regions are nested, the pending error is handled by the handler associated with the next outer WHEN ERROR block.
3. When no outer protected regions can handle the error, and if an ON ERROR statement is in effect, control transfers to the target of the next outer ON ERROR statement (if one is present).
4. If no outer handler is available or can handle the error, the error is passed to VAX BASIC default error handling. Default error handling is equivalent to ON ERROR GOTO 0.

For information on specific run-time errors, refer to Appendix B in this manual.

Chapter 18

Compiler Directives

Compiler directives are instructions that tell VAX BASIC to perform certain operations as it translates a source program. This chapter describes how to control program compilation using compiler directives.

18.1 Introduction

With compiler directives, you can do the following:

- Place program titles and subtitles in the header that appears on each page of the listing file
- Place a program version identification string in both the listing file and the object module
- Start or stop the inclusion of listing information for selected parts of a program
- Start or stop the inclusion of cross-reference information for selected parts of a program
- Include VAX BASIC code from another source file or a text library
- Include CDD/Plus record definitions in a VAX BASIC program
- Record dependency relationships in CDD/Plus
- Display a message at compile time
- Conditionally compile parts of a program
- Terminate compilation

When using compiler directives, follow these rules:

- Directives must begin with a percent sign.
- Directives can be preceded by an optional line number.

- Directives must be the only text on the line (except for %IF-%THEN-%ELSE-%END %IF).
- Directives cannot appear within a quoted string.
- Directives cannot follow an END, END SUB, or END FUNCTION statement.

18.2 Controlling the Compilation Listing

Listing directives let you control the content and appearance of the compilation listing. There are eight compiler listing directives:

- %TITLE places a title string on the first line of the listing header.
- %SBTTL places a subtitle string on the second line of the listing header.
- %IDENT places an identification string on the second line of the listing header and within the object module.
- %PAGE causes VAX BASIC to skip to top-of-form in the output listing.
- %NOLIST causes VAX BASIC to stop accumulating information for the output listing.
- %LIST causes VAX BASIC to resume accumulating information for the output listing.
- %NOCROSS causes VAX BASIC to stop accumulating cross-reference information for the output listing.
- %CROSS causes VAX BASIC to resume accumulating cross-reference information for the output listing.

These directives are described in the following sections.

The listing control directives have no effect if no source program listing is being produced. Similarly, the %CROSS and %NOCROSS directives have no effect if no cross-reference listing is being produced. However, the %IDENT directive places the specified text in the object module whether or not a listing is produced.

18.2.1 The %TITLE and %SBTTL Directives

The %TITLE directive lets you specify a line of text that appears on the first line of every page in the compilation listing. This text line is a quoted string of up to 45 characters and normally contains the source program title and other information.

If the %TITLE directive is the first source text in a module, then the quoted string appears in the first line of every page of the compilation listing. Otherwise, the quoted string appears in the first line of every subsequent page in the compilation listing. That is, if VAX BASIC encounters a %TITLE directive after it has begun creating a page in the output listing, the title information will not appear on that page. Rather, it appears on all of the following pages until it encounters another %TITLE directive.

The quoted string appears in character positions 33 to 81 in the first line of the listing header. %TITLE must appear on its own line. For example:

```
%TITLE "File OPEN Subprogram -- Author Hugh Ristics"
SUB FILSUB (STRING F_NAME)
```

The %SBTTL directive lets you specify a line of text that appears on the second line of every page in the compilation listing (beneath the title). If VAX BASIC encounters a %SBTTL directive after it has begun creating a page in the output listing, the subtitle information will not appear on that page. Rather, it appears on all following pages until it encounters another %SBTTL or %TITLE directive. If you want the subtitle to appear on the first page, the %SBTTL directive must appear directly after the %TITLE directive.

Any number of %SBTTL directives can appear in a source file; thus, you can use subtitle text to identify parts of the source program. As in %TITLE, the text you use in %SBTTL must be a quoted string not exceeding 45 characters. The quoted string appears in the second line of the listing header, in character positions 33 to 81. Note, however, that subtitle information only appears on listing pages that contain the actual source code.

The following example shows the use of both %TITLE and %SBTTL directives. The first line of the listing's first page contains "Payroll Program" and the second line contains "Constant Declarations". When VAX BASIC encounters the %SBTTL directive, the second line on each subsequent page becomes "Subroutines". When VAX BASIC encounters the %SBTTL directive, the second line on each subsequent page becomes "Error Handler".

```
%TITLE "Payroll Program"
%SBTTL "Constant Declarations"
    .
    .
    .
%SBTTL "Subroutines"
    .
    .
    .
%SBTTL "Error Handler"
    .
    .
    .
```

You can use multiple %TITLE directives in a single source file; however, whenever VAX BASIC encounters a %TITLE directive, the %SBTTL information is set to the null string. Therefore, if you want to display subtitle information, each new %TITLE directive should be accompanied by a new %SBTTL directive.

18.2.2 The %IDENT Directive

The %IDENT directive identifies the version of a program module. The identification text must be a quoted string of up to 31 characters. The information contained within the identification text appears in the listing file and the object module. Thus, the map file created by the VMS Linker also contains this information.

The identification text appears in the first 31 character positions of the second line on each subsequent listing page. For instance, in the following example, the %IDENT information appears as the first entry on the second line of the listing. The information is also included in the object module if the compilation produces one. If the linker generates a map listing, this information also appears there.

```
%IDENT "V5.3"
SUB PAY
    .
    .
    .
```

If your source module contains multiple %IDENT directives, VAX BASIC signals a warning and uses the version specified in the first %IDENT directive.

18.2.3 The %PAGE Directive

The %PAGE directive causes VAX BASIC to begin a new page in the listing file. In the following example, the %PAGE directives cause VAX BASIC to skip to a new page in the listing file just before each new subtitle. Note that, in order to have title and subtitle information appear in the heading of each page, you cannot place a line number between the %PAGE, %TITLE, and %SBTTL directives.

```
%TITLE "Payroll Program"
%SBTTL "Constant Declarations"
   .
   .
   .
%PAGE
%SBTTL "Subroutines"
   .
   .
   .
%PAGE
%SBTTL "Error Handler"
   .
   .
   .
```

18.2.4 The %LIST and %NOLIST Directives

%LIST and %NOLIST are complementary directives. The %LIST directive causes VAX BASIC to resume adding information to the listing file, while the %NOLIST directive causes VAX BASIC to stop adding information to the listing file. Therefore, you can control which parts of the source program are to be listed.

In the following example, as soon as VAX BASIC encounters the %LIST directive, it resumes adding new information to the listing file:

```
%TITLE "Payroll Program"
%SBTTL "Constant Declarations"
    .
    .
    .
%NOLIST
    .
    .
    .
%LIST
    .
    .
    .
%PAGE
%SBTTL "Subroutines"
    .
    .
    .
%PAGE
%SBTTL "Error Handler"
    .
    .
    .
```

If you have not requested the creation of a compilation listing, the %LIST and %NOLIST directives have no effect.

If a program line contains a syntax error, VAX BASIC overrides the %NOLIST directive for that line and produces the normal error diagnostics in the listing file.

18.2.5 The %CROSS and %NOCROSS Directives

The %CROSS and %NOCROSS directives are complementary. The %CROSS directive causes VAX BASIC to resume adding cross-reference information, while the %NOCROSS directive causes VAX BASIC to stop adding cross-reference information to the listing file. Therefore, you can specify that only certain parts of the source program are to be cross-referenced.

In the following example, as soon as VAX BASIC encounters the %CROSS directive, it resumes adding new cross-reference information to the listing file:

```
%TITLE "Payroll Program"
%SBTTL "Constant Declarations"
    .
    .
    .
%NOCROSS
    .
    .
    .
%CROSS
    .
    .
    .
%PAGE
%SBTTL "Subroutines"
    .
    .
    .
%PAGE
%SBTTL "Error Handler"
    .
    .
    .
```

If you have not requested the creation of a cross-reference listing, the %CROSS and %NOCROSS directives have no effect.

18.3 Accessing External Source Files

The %INCLUDE directive lets you access VAX BASIC source text from a file into the source program. The %INCLUDE directive also lets you access record definitions in CDD/Plus as well as access source text from a text library. The line on which a %INCLUDE directive resides can be continued, but cannot contain any other directives or statements.

If you are including a source text file, you must supply a file specification. If you do not provide a file type, VAX BASIC uses the default type BAS. For example:

```
%INCLUDE  "KEN.BAS"
```

If you are including a CDD/Plus definition, you must supply a valid VAX CDD/Plus path specification to extract a RECORD definition from CDD/Plus. For example:

```
%INCLUDE %FROM %CDD "CDD$TOP.EMPLOYEE"
```

See Chapter 23, the *VAX BASIC Reference Manual*, and the *VAX Common Data Dictionary Utilities Reference Manual* for more information.

If you are including source text from a text library, you must supply the name of the text module you wish to include as well as the name of the library where the module resides. If you do not specify a library name, VAX BASIC uses the default library, BASIC$LIBRARY. Moreover, if you do not specify a directory name or file type, VAX BASIC uses the default device and the file type TLB.

In the following example, when VAX BASIC encounters the %INCLUDE directive, the compiler searches through the library SYS$LIBRARY:BASIC_LIB.TLB for the specified module DMB_TEST and compiles the text as if it were placed in the position of the %INCLUDE directive:

```
%INCLUDE "DMB_TEST" %FROM %LIBRARY "SYS$LIBRARY:BASIC_LIB.TLB"
```

VAX BASIC supplies the text library BASIC$STARLET located in SYS$LIBRARY. This text library contains condition codes and other symbols defined in the system object and shareable image libraries. Using the definitions from BASIC$STARLET allows you to reference condition codes and other system-defined symbols as local, rather than global symbols.

To create your own text libraries using the VMS Librarian Utility, see the *VMS Librarian Utility Manual*.

All file specifications, CDD/Plus path specifications, text modules, and library specifications must be string literals enclosed in quotes.

The source files accessed with %INCLUDE cannot contain line numbers. This requirement means that all statements in the accessed file are associated with the VAX BASIC line containing the %INCLUDE directive if line numbers are being used. Therefore, if you are using line numbers, a %INCLUDE directive cannot appear before the first line number in a source program. A file accessed by %INCLUDE can itself contain a %INCLUDE directive.

When a program is compiled, VAX BASIC inserts the included text at the point at which it encounters the %INCLUDE directive. The compilation listing identifies any text obtained from an included file by placing a mnemonic in the first character position of the line in which the text appears. "I*n*" specifies text that was either accessed from a source file or from a text library, and "C*n*" specifies a record definition that was accessed from CDD/Plus. Both the I and the C tell you that the text was accessed with the %INCLUDE directive, and *n* tells you the nesting level of the included text.

The %INCLUDE directive is useful when you want to share code among multiple program modules. To do this, you must first create a file that contains the shareable code, then include that file in all the modules that require it. Thus, you reduce the chance of a typographical error.

You can prevent the %INCLUDE file code from appearing in the compilation listing by using the BASIC command qualifier /SHOW=NOINCLUDE or /SHOW=NOCDD_DEFINITIONS. For text files and text library modules, use the qualifier /SHOW=NOINCLUDE. For CDD/Plus definitions, use the qualifier /SHOW=NOCDD_DEFINITIONS.

18.4 Controlling Compilation

VAX BASIC lets you control the compilation of a program by creating and testing *lexical constants*. You create and assign values to lexical constants with the %LET directive. These constants are always LONG integers.

You control the compilation by using the %IF-%THEN-%ELSE-%END %IF directive to test these lexical constants. Thus, you can conditionally:

- Supply different values for program variables and constants
- Skip over part of a program
- Abort a compilation
- Include VAX BASIC source code from another file
- Display informational messages during the compilation

VAX BASIC also supplies the lexical built-in function %VARIANT that can be used to conditionally control compilation.

%IF-%THEN-%ELSE-%END %IF uses *lexical expressions* to determine whether to execute directives in the %THEN clause or the %ELSE clause. The following sections describe the use of:

- Lexical constants and expressions (%LET directive)
- %VARIANT
- %ABORT
- %PRINT
- %IF-%THEN-%ELSE-%END %IF

18.4.1 The %LET Directive

The %LET directive creates and assigns values to lexical constants. Lexical constants are always LONG integers. These constants control the execution of the %IF-%THEN-%ELSE-%END %IF directive.

All lexical constants must be created with %LET before they can be used in a %IF-%THEN-%ELSE-%END %IF directive, and each lexical constant must be created with a separate %LET directive. All lexical constant names must also be preceded by a percent sign and cannot end with a dollar sign or percent sign.

A lexical expression can be:

- A lexical constant
- An integer literal
- A lexical built-in function (%VARIANT)
- Any combination of these, separated by logical, relational, or arithmetic operators

The %LET directive lets you create constants that control conditional compilation. For example:

```
%LET %debug_on = 0%
```

See Section 18.4.5 for an example of using %LET with %IF-%THEN-%ELSE.

18.4.2 The %VARIANT Directive

The %VARIANT directive is a built-in lexical function that returns an integer. The value of this returned integer is determined by:

- The SET VARIANT command when a program is compiled in the BASIC environment.
- The /VARIANT qualifier when a program is compiled from the system command level or from within the BASIC environment.

The %VARIANT function returns the variant value set with either of these methods.

The default value for the %VARIANT function is zero. See Section 18.4.5 for an example of controlling compilation with %VARIANT.

18.4.3 The %ABORT Directive

The %ABORT directive terminates the compilation and displays a message you provide.

The text must be a quoted string literal. This information is displayed to SYS$ERROR and in the compilation listing if one is being created. VAX BASIC stops the compilation and terminates the listing file as soon as it encounters a %ABORT directive, and so VAX BASIC does not perform syntax checking on the remainder of the program. See Section 18.4.5 for an example of using %ABORT.

18.4.4 The %PRINT Directive

The %PRINT directive allows you to insert a message into your source code that the VAX BASIC compiler displays at compile time.

The text must be a quoted string literal. This information is displayed to SYS$ERROR and in the compilation listing if one is being created. VAX BASIC prints the message specified as soon as it encounters a %PRINT directive. See Section 18.4.5 for an example of using %PRINT.

18.4.5 The %IF-%THEN-%ELSE-%END %IF Directive

The %IF-%THEN-%ELSE-%END %IF directive lets you do the following things conditionally:

- Compile source text
- Execute another compiler directive

This directive differs from all others in that it can appear anywhere in a program where a space is allowed, except within a quoted string.

You must include %END %IF. Otherwise, the rest of the source program becomes part of the %THEN or %ELSE clause. You must also include a lexical expression and some VAX BASIC source code.

The truth or falsity of the lexical expression determines whether VAX BASIC compiles the source code in the %THEN clause or the %ELSE clause. If the lexical expression is true, VAX BASIC does not compile the source code in the %ELSE clause. If the lexical expression is false, VAX BASIC does not compile the source code in the %THEN clause. However, VAX BASIC does check for lexical errors (such as illegally formed numeric constants) in the

uncompiled block of code. If an uncompiled block of code contains a lexical error, VAX BASIC signals an error.

Even though VAX BASIC compiles only one block of code in an %IF-%THEN-%ELSE-%END-%IF directive, you cannot use the same line number in both a %THEN block and an %ELSE block. If you specify the same line number, the first occurrence of the line number is replaced by the second when the program is compiled.

The following example uses the %VARIANT directive, which returns the value set by the SET VARIANT command or /VARIANT qualifier:

```
%IF (%VARIANT = 2%)
%THEN DECLARE LONG int_array(100)
%ELSE DECLARE WORD int_array(100)
%END %IF
```

This directive allows for two possibilities. If you compile this program with a /VARIANT=2 qualifier, then VAX BASIC creates an array of longword integers. If you compile this program with any other variant value, VAX BASIC creates an array of word integers.

Because %IF can appear within a program line, you can express the same directive this way:

```
DECLARE %IF (%VARIANT=2%) %THEN LONG %ELSE WORD %END %IF int_array(100)
```

A %THEN or %ELSE clause can also contain other compiler directives. For example, the following program creates the lexical constant *%my_constant* and assigns it a value of 8. The %IF directive evaluates the conditional expression *((%my_constant + %VARIANT) >= 10%)*. If this expression is true, VAX BASIC executes the %THEN clause, aborting the compilation and issuing an error message. If the expression is false, VAX BASIC prints the specified message and continues to compile your program without aborting the compilation.

```
%LET %my_constant = 8%
%IF ( (%my_constant + %VARIANT) >= 10% )%THEN
    %ABORT "Cannot compile with VARIANT >= 2"
    %ELSE
    %PRINT "Successful Compilation"
%END %IF
```

The compilation listing shows you which clause was actually compiled.

18.5 Record Dependency Relationships in CDD/Plus

By using the %INCLUDE %FROM %CDD or the %REPORT %DEPENDENCY directives in conjunction with the /DEPENDENCY_DATA qualifier in the BASIC command, you can record dependency relationships in a CDO dictionary between a compiled module entity and included records or other referenced dictionary entities. This functionality is available only if you have CDD/Plus Version 4.0 or higher installed on your system.

See Chapter 23 for more information.

Chapter 19

Data Representation

This chapter describes how to represent data using VAX BASIC on the VMS operating system.

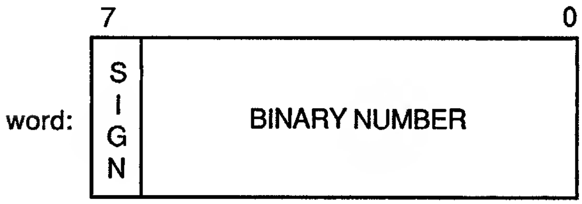
19.1 Integer Format

There are three ways in which integer data can be represented: byte, word, and longword. Note that negative integer values are stored in two's complement format. The following sections describe each of these formats.

19.1.1 Byte-Length Integer Format

Byte-length integers are in the range –127 to 128 and are stored as a single byte (8 bits), starting on an arbitrary byte boundary. Bits are labeled from the right, 0 through 7. See Figure 19–1.

Figure 19–1: Byte-Length Integer Format



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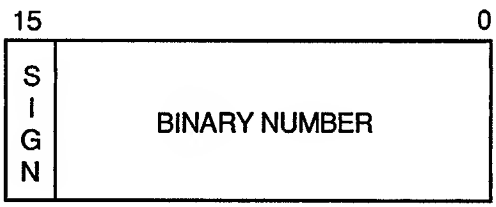
19.1.2 Word-Length Integer Format

Word-length integers are in the range –32768 to 32767 and are stored as two contiguous bytes, starting on an arbitrary byte boundary. Bits are labeled from the right, 0 through 15. See Figure 19–2.

Figure 19–2: Word-Length Integer Format



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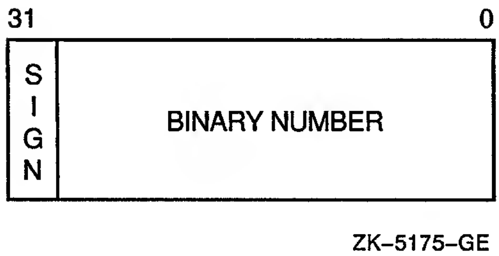
19.1.3 Longword Integer Format

Longword integers are stored as four contiguous bytes, starting on an arbitrary byte boundary. Values are in the range –2147483647 to 2147483647. See Figure 19–3.

Figure 19–3: Longword Integer Format



19.2 Real Number Format

Real numbers, like integers, can be represented in varying formats. These formats include SINGLE floating-point, DOUBLE floating-point, GFLOAT floating-point, HFLOAT floating-point, and packed DECIMAL format. The following sections describe each of these formats.

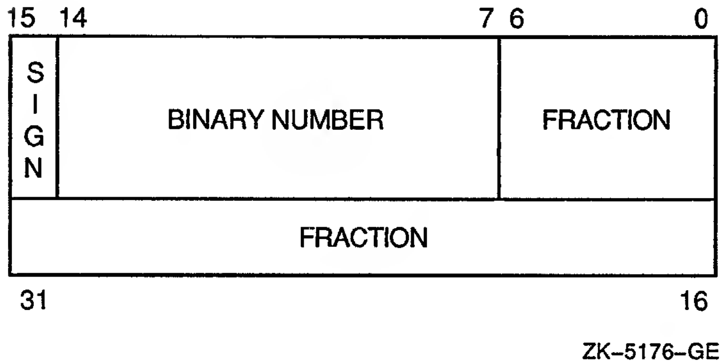
19.2.1 SINGLE Floating-Point Number Format (F_floating)

F_floating (single-precision) floating-point numbers are stored as four contiguous bytes, starting on an arbitrary byte boundary. Bits are labeled from the right, 0 through 31.

The format for single-precision is sign magnitude, with bit 15 the sign bit, bits 14 to 7 an excess-128 binary exponent, and bits 6 through 0 and 31 through 16 a normalized 24-bit fraction with the redundant most significant fraction bit not represented. See Figure 19–4. The 8-bit exponent field encodes the values between 0 and 255, inclusive.

An exponent value of 0 together with a sign bit of 0 indicates that the F_floating number has a value of 0. Exponent values between 1 and 255 indicate true binary exponents of –127 through 127. An exponent value of 0, together with a sign bit of 1, is taken as reserved. (Floating-point instructions processing a reserved operand take a reserved operand fault.) The magnitude of an F_floating number is in the approximate range $.29 * 10^{-38}$ through $* 10^{38}$. The precision of an F_floating number is approximately one part in 2^{23} (approximately 7 decimal digits).

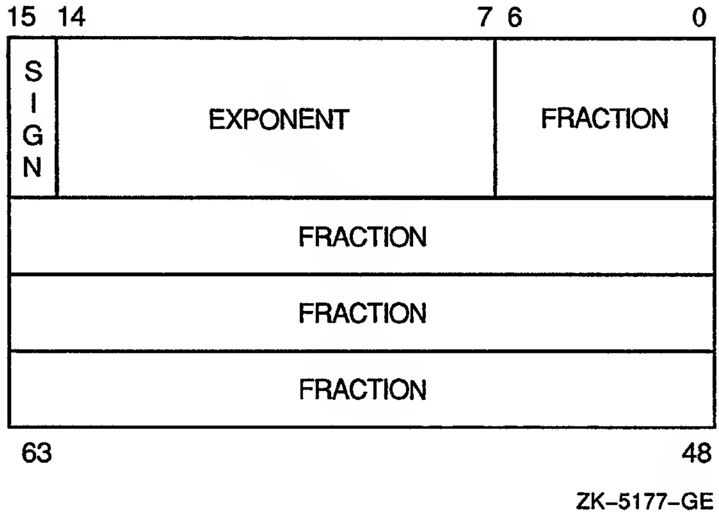
Figure 19–4: Single-Precision Real Number Format



19.2.2 DOUBLE Floating-Point Number Format (D_floating)

Double-precision real number format consists of eight contiguous bytes, starting on an arbitrary byte boundary. Bits are labeled from the right, 0 through 63. See Figure 19–5. The form of a D_floating number is identical to the F_floating form, except for an additional 32 low-significance fraction bits. Within the fraction, bits increase in significance from 48 to 63, 32 through 47, 16 through 31, and 0 through 6. The exponent conventions and approximate range of values are the same for both D_floating and F_floating numbers. The precision of a D_floating number is approximately one part in 2^{55} (approximately 16 decimal digits).

Figure 19–5: Double-Precision Real Number Format



19.2.3 GFLOAT Floating-Point Number Format (G_floating)

The G_floating floating-point number format is eight contiguous bytes, starting on an arbitrary byte boundary. Bits are labeled from the right, 0 through 63. The form of a G_floating number is sign magnitude with bit 15 the sign bit, bits 14 through 4 an excess-1024 binary exponent, and bits 3 through 0 and 63 through 16 a normalized 53-bit fraction with the redundant most significant fraction bit not represented.

Within the fraction, bits of increasing significance go 48 through 63, 32 through 47, 16 through 31, and 0 through 3. The 11-bit exponent field encodes the values 0 through 2047.

An exponent value of 0 together with a sign bit of 0 indicates that the G_floating number's value is 0. Exponent values between 1 and 2047 indicate true binary exponents between –1023 and 1023. The value of a G_floating number is in the approximate range $.56 * 10^{-308}$ to $.9 * 10^{308}$; the precision is approximately one part in 2^{52} (approximately 15 decimal digits). Note that both double and G_floating formats require 8 bytes. G_floating format provides a greater range, but less precision than double.

19.2.4 HFLOAT Floating-Point Number Format (H_floating)

An H_floating floating-point number is 16 contiguous bytes, starting on an arbitrary byte boundary. H_floating format combines a large range with extensive precision, but requires twice the amount of storage of double and G_floating numbers. The bits are labeled from the right 0 through 127. The form of an H_floating number is sign magnitude with bit 15 the sign bit, bits 14 to 0 an excess –16384 binary exponent, and bits 127 to 16 a normalized 113-bit fraction with the redundant most significant fraction bit not represented.

Within the fraction, bits of increasing significance go 112 through 127, 96 through 111, 80 through 95, 64 through 79, 48 through 63, 32 through 47, and 16 through 31. The 15-bit exponent field encodes the values 0 through 32767.

An exponent value of 0 together with a sign bit of 0 indicates the H_floating number has a value of 0. Exponent values between 1 and 32767 indicate true binary exponents between –16383 and 16383. The value of an H_floating number is in the approximate range $.84 * 10^{4932}$ through $.59 * 10^{4932}$. The precision of an H_floating number is approximately one part in 2^{112} (approximately 33 decimal digits).

19.3 Packed Decimal Number Format

The DECIMAL data type is useful for storing numbers with a fixed decimal point. DECIMAL numbers are stored as a precise representation of the value stored within the constraints of the specified number of fractional digits. A packed decimal string is a contiguous sequence of bytes in memory. The address A and length L are sufficient to specify a packed decimal string, but note that L is the number of digits, not bytes, in the string. Every byte of a packed decimal string is divided into two 4-bit fields (nibbles), each of which must contain decimal digits, except the low nibble of the last byte, which must contain a sign. The representation for the digits and sign is as follows:

Digit or Sign	Decimal	Hexadecimal
0	0	0
1	1	1
2	2	2

Digit or Sign	Decimal	Hexadecimal
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9
+	10,12,14, or 15	A,C,E, or F
–	11 or 13	B or D

Despite the options, the preferred sign representation is 12 for positive and 13 for negative. The length L is the number of digits in the packed decimal string (not counting the sign) and must be in the range 1 through 31. If the number of digits is odd, the digits and the sign fit into ((L/2) + 1) bytes; when the number of digits is even, an extra "0" digit must appear in the high nibble (bits 7 to 4) of the first byte.

The address A of the string specifies the byte of the string containing the most significant digit in its high nibble. Digits of decreasing significance are assigned to increasing byte addresses and from high nibble to low nibble within a byte.

Note that the decimal point is specified by the descriptor for the packed decimal string. See Section 19.6.

19.4 String and Array Descriptor Format

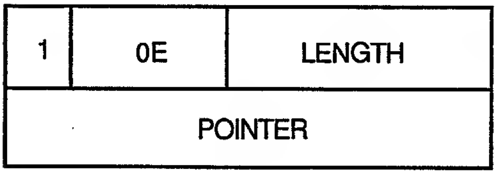
A descriptor is a VMS data structure that describes the parameter being passed. The following sections describe the formats for both string and array descriptors.

19.4.1 Fixed-Length String Descriptor Format

A fixed-length string descriptor consists of two longwords. The first word of the first longword contains a value equal to the string's length. The third byte contains a 14 (0E hexadecimal; the VMS code describing an ASCII character string). The fourth byte contains a 1. The second longword is a pointer containing the address of the string's first byte. See Figure 19–6.

For more information, see the *Introduction to VMS System Routines* for the VAX Procedure Calling and Condition Handling Standard.

Figure 19–6: Fixed-Length String Descriptor Format



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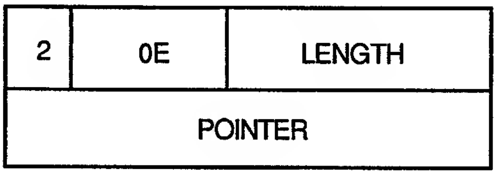
19.4.2 Dynamic String Descriptor Format

A dynamic string descriptor consists of two longwords. The first word of the first longword contains a value equal to the string's length. The third byte contains a 14 (0E hexadecimal; the VMS code describing an ASCII character string). The fourth byte contains a 2. The second longword is a pointer containing the address of the string's first character. See Figure 19–7 for more information.

Figure 19–7: Dynamic String Descriptor Format



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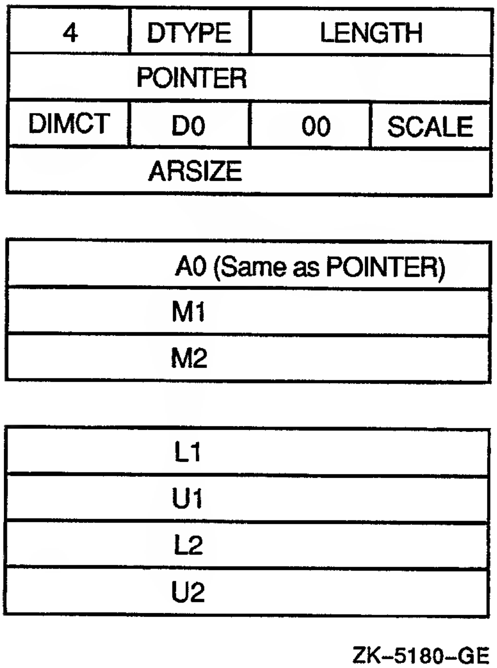
19.5 Array Descriptors

VAX BASIC creates class A array descriptors (DSC$K_CLASS_A) for all arrays except virtual arrays. Virtual array descriptors differ in format and can be manipulated only with VAX BASIC Run-Time Library support routines. Most array descriptors created by VAX BASIC describe the actual data in an array. Some arrays, however, have elements that differ in length from one another. VAX BASIC arrays of this type include both dynamic string arrays and arrays of any datatype which have appeared in MAP DYNAMIC and REMAP statements. An array descriptor for an array of this type describes an array of element descriptors. One element descriptor exists for each array element and points to the actual data.

As shown in Figure 19–8, VAX BASIC array descriptors consist of three blocks of information. The first block, the prototype block, is always four longwords in length. The second and third blocks, the multiplier and bounds blocks, vary in length depending on the number of dimensions for the array being described. The sections following Figure 19–8 describe each block.

Figure 19–8: Array Descriptor Format



19.5.1 The Prototype Block

In the prototype block, if the data type is not an aligned bit string or packed decimal string, the first word of the first longword contains a value denoting the number of bytes in each array element.

The length of an aligned bit string array element is specified in bits. The length of a packed decimal string array element is the number of 4-bit digits, not including the sign.

For arrays requiring a descriptor for each element, the value in this field is the length of the descriptor for the element. Dynamic string arrays and most remapped arrays require 8 bytes for the element descriptor. Remapped packed decimal arrays require 12 bytes for the element descriptor.

The third byte of the first longword contains a code indicating the VMS data type of the array described by the descriptor. For arrays requiring element descriptors, the value is 24 (the VMS literal DSC$K_DTYPE_DSC and the value 18 hexadecimal). For other arrays, the value reflects the actual data type of the array. The fourth byte denotes the class of the array descriptor and will always have the value 4 (DSC$K_CLASS_A).

The second longword is a pointer containing the address of the first element of the array or the first element descriptor. The first byte of the third longword contains a scale factor for packed decimal arrays and for DOUBLE arrays in programs compiled with a scale factor. The second byte specifies the number of digits in each packed decimal array element; for array types other than packed decimal, this byte is zero. The third byte contains array flags indicating that the multiplier and bounds blocks are present (hexadecimal D0). The fourth byte contains a value equal to the number of dimensions in the array. The fourth longword contains the total size of the array in bytes.

19.5.2 The Multiplier Block

For arrays where all dimensions have a lower bound of zero, the first longword (A0) of the multiplier block has the same value as the second longword of the prototype block (the pointer). For arrays with dimensions that possess nonzero lower bounds, the value of A0 is the address of the first array element adjusted to account for the nonzero lower bounds in all dimensions. You can use this field in the descriptor to access arrays without consideration of the lower bounds of the array dimensions when computing the element address.

The multiplier block contains an additional longword for each dimension of the array. Each longword contains the number of elements in the corresponding dimension (the upper bound minus the lower bound plus 1).

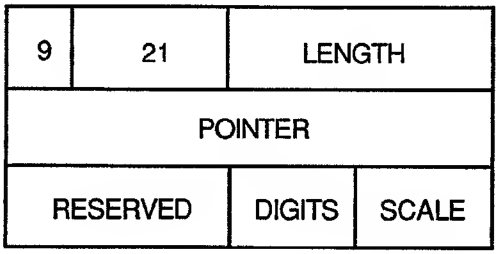
19.5.3 The Bounds Block

The third block, the bounds block, consists of one longword pair for each dimension of the array. The first longword of each pair specifies the lower bound of the corresponding dimension and the second longword specifies the upper bound of that dimension.

19.6 Decimal Scalar String Descriptor (Packed Decimal String Descriptor)

A single descriptor form gives decimal size and scaling information for both scalar data and simple strings. See Figure 19–9 for more information.

Figure 19–9: Decimal Scalar String Descriptor



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For packed decimal strings, the length field contains the number of 4-bit digits (not including the sign). The pointer field contains the address of the first byte in the packed decimal string. The scale field contains a signed power-of-ten multiplier to convert the internal form to the external form. For example, if the internal number is 123 and the scale field is +1, then the external number is 1230. The digits field is 0; the number of digits is computed from the length field. The reserved field must be zero.

Part III
Using VAX BASIC Features on VMS

Chapter 20

Advanced File Input and Output

This chapter describes some of the more advanced I/O features available in VAX BASIC. For more information on I/O to RMS disk files, see Chapter 15 in this manual.

20.1 Introduction

This chapter discusses the following topics:

- RMS I/O to ANSI magnetic tapes
- Device-specific I/O to magnetic tapes (including TK50 devices), disks, and unit record devices
- I/O to mailboxes
- Network I/O

When you do not specify a file name in the OPEN statement, the I/O you perform is said to be *device-specific*. This means that read and write operations (GET and PUT statements) are performed directly to or from the device. For example:

```
OPEN "MTA2:" FOR OUTPUT AS FILE #1
OPEN "MTA1:PARTS.DAT" FOR INPUT AS FILE #2, SEQUENTIAL
```

Because the file specification in the first line does not contain a file name, the OPEN statement opens the tape drive for device-specific I/O. The second line opens an ANSI-format tape file using RMS because a file name is part of the file specification.

The following sections describe both I/O to ANSI-format magnetic tapes and device-specific I/O to magnetic tape, unit record, and disk devices.

20.2 RMS I/O to Magnetic Tape

VAX BASIC supports I/O to ANSI-formatted magnetic tapes. When performing I/O to ANSI-formatted magnetic tapes, you can read or write to only one file to a magnetic tape at a time, and the files are not available to other users. ANSI tape files are RMS sequential files.

20.2.1 Allocating and Mounting a Tape

You should allocate the tape unit to your process before starting file operations. For example:

```
$ ALLOCATE MT1:
```

This command assigns tape drive MT1: to your process. You must also set the tape density and label with the MOUNT command. Optionally, you can specify a logical name to assign to the device, in this case, TAPE:

```
$ MOUNT/DENSITY=1600 MT1: VOL001 TAPE
```

When mounting a TK50, you cannot specify a density.

If the records do not specify the size of the block (no value in HDR 2), specify the BLOCKSIZE as part of the MOUNT command. For example:

```
$ MOUNT/DENSITY=1600/BLOCKSIZE=128 MT1: VOL020 TAPE
```

Alternatively, you can use the $MOUNT system service to mount tapes.

20.2.2 Opening a Tape File for Output

To create and open a magnetic tape file for output, you use the OPEN statement. For instance, the following statement opens the file PARTS.DAT and writes 256-byte records that are blocked four to a physical tape block of 1024 bytes.

```
OPEN "MT1:PARTS.DAT" FOR OUTPUT AS FILE #2%, SEQUENTIAL FIXED,  &
                RECORDSIZE 256%, BLOCKSIZE 4%
```

Specifying FIXED record format creates ANSI F format records. Specifying VARIABLE creates ANSI D format records. If you do not specify a record format, the default is VARIABLE.

NOTE

Every record in an ANSI D formatted file is prefixed by a 4-byte header giving the record length in decimal ASCII digits. The

length includes the 4-byte header. VAX BASIC adds the 4-byte header to the record size when calculating block size. The header is transparent to your program.

If you do not specify a block size, VAX BASIC defaults to one record per block. For small records, this can be inefficient; the tape will contain many interrecord gaps.

20.2.3 Opening a Tape File for Input

To open an existing magnetic tape file, you also use the OPEN statement. For example, the following statement opens the file PAYROLL.DAT. If you do not specify a record size or a block size, VAX BASIC defaults to the values in the header block. If you do not specify a record format, VAX BASIC defaults to the format present in the header block (ANSI F or ANSI D). You must specify ACCESS READ if the tape is not write-enabled. For example:

```
100    OPEN "TAPE:PAYROLL.DAT" FOR INPUT AS FILE #4%
                ,ACCESS READ
```

20.2.4 Positioning a Tape

NOREWIND positions the tape for reading and writing as follows:

- Specifying NOREWIND when you create a file positions the tape at the logical end-of-tape and leaves the unit open for writing. If you omit NOREWIND, you start writing at the beginning of the tape (BOT), logically deleting all subsequent files.
- Specifying NOREWIND when you open an existing file starts a search for the file at the current position. The search continues to the logical end-of-tape. If the record is not found, VAX BASIC rewinds and continues the search until reaching the logical end-of-tape again. Omitting NOREWIND tells VAX BASIC to rewind the tape and search for the file name until reaching the end-of-tape. In either case, you receive an error message if the file does not exist.

For example, the following statement opens PAYROL.DAT after advancing the tape to the logical end-of-tape. If you omit NOREWIND, the file opens at the beginning of the tape, logically deleting all subsequent files.

```
OPEN "MT1:PAYROL.DAT" FOR OUTPUT AS FILE #1% &
        ,ORGANIZATION SEQUENTIAL, NOREWIND
```

Note that you cannot specify REWIND; to avoid rewinding the tape, omit the NOREWIND keyword.

20.2.5 Writing Records to a File

The PUT statement writes sequential records to the file. The following program writes a record to the file. Successive PUT operations write successive records.

Example

```
OPEN "MT0:TEST.DAT" FOR OUTPUT AS FILE #2, &
               SEQUENTIAL FIXED, RECORDSIZE 20%
B$ = ""
WHILE B$ <> "NO"
     LINPUT "Name"; A$
     MOVE TO #2, A$ = 20
     PUT #2
     LINPUT "Write another record"; B$
NEXT
CLOSE #2
END
```

Each PUT writes one record to the file. If your OPEN statement specifies a RECORDSIZE clause, the record buffer length equals RECORDSIZE or the map size. For example:

```
RECORDSIZE 60%
```

This clause specifies a record length and a record buffer size of 60 bytes. You can specify a record length between 18 and 8192 bytes. The default is 132 bytes.

If you specify a MAP clause and no RECORDSIZE clause, then the record size is the size of the map.

If you also specify BLOCKSIZE, the size of the buffer equals the value in BLOCKSIZE multiplied by the record size. For example:

```
RECORDSIZE 60%, BLOCKSIZE 4%
```

These clauses specify a logical record length of 60 bytes and a physical tape record size of 240 bytes (60 * 4). You specify BLOCKSIZE as an integer number of records. RMS rounds the resulting value to the next multiple of four. The total I/O buffer length cannot exceed 8192 bytes. The default is a buffer (tape block) containing one record.

To write true variable-length records, use the COUNT clause with the PUT statement to specify the number of bytes of data written to the file. Without COUNT, all records equal the length specified by the RECORDSIZE clause when you opened the file.

20.2.6 Reading Records from a File

The GET statement reads one logical record into the buffer. For example, in the following program, the first GET reads a group of four records (a total of 80 bytes) from the file on channel #5 and transfers the first 20 bytes to the record buffers. Successive GET operations read 20 byte records to the record buffer performing an I/O to the tape every 4 records.

Example

```
OPEN "MT0:TEST.DAT" FOR INPUT AS FILE #5%, &
       ORGANIZATION SEQUENTIAL FIXED, RECORDSIZE 20%, &
       BLOCKSIZE 4%, ACCESS READ
B$ = ""
WHILE B$ <> "NO"
      GET #5
      MOVE FROM #5, A$ = 20
      PRINT A$
      LINPUT "Do you want another record"; B$
NEXT
CLOSE #5
END
```

20.2.7 Controlling Tape Output Format

Magnetic tape physical records range from 18 to 8192 bytes. With RMS tapes, you can optionally specify this size in the BLOCKSIZE clause as a positive integer indicating the number of records in each block. VAX BASIC then calculates the actual size in bytes. Thus, a fixed-length file on tape with 126 byte records can have a block size between 1 and 64, inclusive. The default is 126 bytes (one record per block).

For instance, in the following example of an OPEN statement, the RECORDSIZE clause defines the size of the records in the file as 90 bytes, and BLOCKSIZE defines the size of a block as 12 records (1080 bytes). Thus, your program contains an I/O buffer of 1080 bytes. Each physical read or write operation moves 1080 bytes of data between the tape and this buffer. Every twelfth GET or PUT operation causes a physical read or write. The next eleven GET or PUT operations only move data into or out of the I/O buffer. Specifying a block size larger than the default can reduce overhead by eliminating some physical reading and writing to the tape. In addition, specifying a large block size conserves space on the tape by reducing the number of interrecord gaps (IRGs). In the example, a block size of 12 saves time by accessing the tape only after every twelfth record operation.

```
OPEN "MTO:[SMITH]TEST.SEQ" FOR OUTPUT AS FILE #12% &
                ,ORGANIZATION SEQUENTIAL FIXED, RECORDSIZE 90% &
                ,BLOCKSIZE 12%
```

Through RMS, VAX BASIC controls the blocking and deblocking of records. RMS checks each PUT operation to see if the specified record fits in the tape block. If it does not, RMS fills the rest of the block with circumflexes (blanks) and starts the record in a new block. Records cannot span blocks in magnetic tape files.

When you read blocks of records, your program can issue successive GET statements until it locates the fields of the record you want. For example, the following program finds and displays a record on the terminal. You can invoke the RECOUNT function to determine how many bytes were read in the GET operation.

Example

```
MAP  (XXX)  NA.ME$ = 5%, address$ = 20%

OPEN "MTO:FILE.DAT" FOR INPUT AS FILE #4%, &
           SEQUENTIAL FIXED, MAP XXX, ACCESS READ

NA.ME$ = ""
GET #4 UNTIL NA.ME$ - "JONES"
PRINT NA.ME$;  "LIVES AT "; address$

CLOSE #4

END
```

20.2.8 Rewinding a Tape

With the RESTORE # statement, you can rewind the tape to the start of the currently open file.

Example

```
OPEN  "MTO:FTF.DAT" FOR INPUT AS FILE #2%, ACCESS READ
GET #2%
    .
    .
    .
RESTORE #2%
GET #2%
```

You cannot rewind past the beginning of the currently open file.

20.2.9 Closing a File

The CLOSE statement ends I/O to the file. For example, the following statement ends input and output to the file open on channel #6:

```
CLOSE #6%
```

If you opened the file with ACCESS READ, CLOSE has no further effect. If you opened the file without specifying ACCESS READ and the tape is not write-locked (that is, if the plastic write ring is in place), VAX BASIC does the following:

- Writes the file trailer labels and two end-of-file marks following the last record
- Backspaces over the last end-of-file mark

VAX BASIC does not rewind the tape.

20.3 Device-Specific I/O

Device-specific I/O lets you perform I/O directly to a device. The following sections describe device-specific I/O to unit record devices, tapes, and disks.

20.3.1 Device-Specific I/O to Unit Record Devices

You perform device-specific I/O to unit record devices by using only the device name in the OPEN statement file specification. You should allocate the device at DCL command level before reading or writing to the device. For example, this command allocates a card reader:

```
$ ALLOCATE CR1:
```

Once the device is allocated, you can read records from it.

Example

```
MAP  (DNG)  A% = 80%
OPEN  "CR1:"  FOR INPUT AS FILE #1%, ACCESS READ, MAP DNG
GET #1%
```

VAX BASIC treats the device as a file, and data is read from the card reader as a series of fixed-length records.

20.3.2 Device-Specific I/O to Magnetic Tape Devices

When performing device-specific I/O to a tape drive, you open the physical device and transfer data between the tape and your program. GET and PUT statements perform read and write operations. UPDATE and DELETE statements are invalid when you perform device-specific I/O.

20.3.2.1 Allocating and Mounting a Tape

You must allocate the tape unit to your process before starting file operations. For example, the following command line assigns tape drive MT1: to your process:

```
$ ALLOCATE MT1:
```

Use the DCL command MOUNT and the /FOREIGN qualifier to mount the tape. For example:

```
$ MOUNT/FOREIGN MT1:
```

If your program needs a blocksize other than 512 bytes, or a particular tape density, specify these characteristics with the MOUNT command as well. For example:

```
$ MOUNT/FOREIGN/BLOCKSIZE=1024/DENSITY=1600 MT1:
```

When reading a foreign tape, you must make sure the /BLOCKSIZE qualifier has a value at least as large as the largest record on the tape.

20.3.2.2 Opening a Tape File for Output

To create and open the magnetic tape for output, you use the OPEN statement. For example, the following statement opens tape drive MT1: for writing. It is important to use the SEQUENTIAL VARIABLE clause unless the records are fixed. In contrast to ANSI tape processing, RMS does not write record length headers or variable-length records to foreign tapes. If you specify SEQUENTIAL VARIABLE, you should have some way to determine where records begin and end.

```
OPEN  "MT1:"  FOR OUTPUT AS FILE #1%,          &
        ORGANIZATION SEQUENTIAL VARIABLE
```

20.3.2.3 Opening a Tape File for Input

To access a tape with existing data, you also use the OPEN statement. For example, the following statement opens the tape unit MT2:.

```
OPEN  "MT2:"  AS FILE #2%
```

Depending on how you access records, there are two ways to open a foreign magnetic tape. If your program uses dynamic buffering and MOVE statements, open the file with no RECORDSIZE clause. RMS will provide the correct buffer size for VAX BASIC. Do not specify a BLOCKSIZE value or ORGANIZATION clause with the OPEN statement.

If your program uses MAP and REMAP statements, but you do not know how long the records are, specify a MAP that is as large as the value you specified for the BLOCKSIZE qualifier when mounting the tape. Do not specify a BLOCKSIZE value or ORGANIZATION clause with the OPEN statement.

When processing records, each GET operation will read one physical record whose size is returned in RECOUNT. If you are using a map only, the first *n* bytes (where *n* is the value returned in RECOUNT) are valid.

20.3.2.4 Writing Records to a File

The PUT statement writes records to the file in sequential order.

Example

```
OPEN "MT0:" FOR OUTPUT AS FILE #9%, &
          SEQUENTIAL VARIABLE
INPUT "NAME";NA.ME$
MOVE TO #9%, NA.ME$
PUT #9%
```

The last line writes the contents of the record buffer to the device. Successive PUT operations write successive records.

The default record length (and, therefore, the size of the buffer) is 132 bytes. The RECORDSIZE attribute causes VAX BASIC to read or write records of a specified length. For instance, the following statement opens tape unit MT0: and specifies records of 900 characters. You must specify an even integer larger than or equal to 18. If you specify a buffer length less than 18, VAX BASIC signals an error. If you try to write a record longer than the buffer, VAX BASIC signals the error “Size of record invalid” (ERR=156).

```
OPEN "MT0:" FOR INPUT AS FILE #1%, RECORDSIZE 900%
```

To write records shorter than the buffer, include the COUNT clause with the PUT statement. For example, the following statement writes a 56-character record to the file open on channel #6. If you do not specify COUNT, VAX BASIC writes a full buffer. You can specify a minimum count of 18, and a maximum count equal to the buffer size. When writing records to a foreign magnetic tape, neither VAX BASIC nor RMS prefixes the records with any count bytes.

```
PUT #6%, COUNT 56%
```

20.3.2.5 Reading Records from a File

The GET statement reads records into the buffer. For instance, the following program reads a record into the buffer, prints a string field, and rewinds the file before closing. Successive GET operations read successive records. VAX BASIC signals the error "End of file on device" (ERR=11) if you encounter a tape mark during a GET operation. If you trap this error and continue, you can skip over any tape marks. The system variable RECOUNT is set to the number of bytes transferred after each GET operation.

Example

```
OPEN "MT1:" FOR INPUT AS FILE #1%, ACCESS READ
GET #1%
MOVE FROM #1%, A$ = RECOUNT
PRINT A$
RESTORE #1%
CLOSE #1%
```

20.3.2.6 Rewinding a Tape

When you mount a magnetic tape, the system will position the tape at the load point (BOT). Your program can rewind the tape during program execution with the RESTORE statement.

Example

```
OPEN "MT1:" FOR OUTPUT AS FILE #2%, ACCESS READ
    .
    .
    .
PUT #2%
RESTORE #2%
INPUT "NEXT RECORD"; NXTRECBB%
```

If you rewind a tape opened without ACCESS READ before closing it, you erase all data written before the RESTORE operation.

20.3.2.7 Closing a Tape

The CLOSE statement ends I/O to the tape. For example, the following statement ends input and output to the tape open on channel #12.

```
CLOSE #12%
```

If you opened the file with ACCESS READ, CLOSE has no further effect. If you opened the file without specifying ACCESS READ and the tape is not write-locked (that is, if the plastic write ring is in place), VAX BASIC does the following:

- Writes file trailer labels and two end-of-file marks following the last record
- Backspaces over the last end-of-file mark

The tape is not rewound unless you specified RESTORE in your program.

20.3.3 Device-Specific I/O to Disks

When performing device-specific I/O to disks, you write and read data with PUT and GET statements. The data must fit in 512-byte blocks, and you must do your own blocking and deblocking with MAP/REMAP or MOVE statements. Note that, when accessing disks with device-specific I/O operations, you are performing logical I/O. Because of this, you should be careful not to overwrite block number zero, which is often the disk's boot block. You must have LOG_IO privileges to perform these operations.

The following sections describe device-specific I/O to disks.

20.3.3.1 Assigning and Mounting a Disk

You must allocate a disk unit to your process before starting operations. For example, the following command line assigns disk DUA3: to your process:

```
$ ALLOCATE DUA3:
```

When you perform I/O directly to a disk, you must mount the disk with the MOUNT command before accessing it. For example:

```
$ MOUNT/FOREIGN DUA3:
```

You can then open the disk for input or output.

20.3.3.2 Opening a Disk File for Output

To create and open the disk file, you use the OPEN statement. For example:

```
OPEN "DUA3:" FOR OUTPUT AS FILE #2%, SEQUENTIAL FIXED, &
       RECORDSIZE=512
```

You can then write data to the disk.

The record size determined by the MAP or RECORDSIZE clause must be an integer multiple of 512 bytes.

20.3.3.3 Opening a Disk File for Input

To open an existing disk file, you also use the OPEN statement. For example:

```
OPEN "DUA1:" FOR INPUT AS FILE #4%, SEQUENTIAL FIXED, &
       RECORDSIZE=512
```

You can then read data from the disk.

The record size determined by the MAP or RECORDSIZE clause must be an integer multiple of 512 bytes. The default is 512.

Specify ACCESS READ in the OPEN statement if you only plan to read from the disk.

20.3.3.4 Writing Records to a Disk File

You write data by defining a record buffer and writing the data to the file with PUT statements. For example, the following program writes eight 64 byte records into each 512-byte block on the disk. When your program fills one block, writing continues in the next. The FILL field in the MOVE statement positions the data in the block.

Example

```
INPUT "HOW MANY RECORDS TO WRITE"; J%
OPEN "DBB2: FOR OUTPUT AS FILE #2%, SEQUENTIAL FIXED, &
      RECORDSIZE=512
FOR K% = 1% TO J%
   FOR I% = 0% TO 7%
        INPUT "NAME OF BOOK"; BOOK_NAME$
        INPUT "RETRIEVAL NUMBER"; RET_NUM%
        INPUT "SUBJECT AREA"; SUBJ$
        MOVE TO #2%, FILL$ = I% * 64%, BOOK_NAME$, RET_NUM%, SUBJ$
   NEXT I%
PUT #2%
NEXT K%
CLOSE #2
```

When you write records, VAX BASIC does not prefix the records with any count bytes.

20.3.3.5 Reading Records from a Disk File

You read data by defining a record buffer and reading the data from the device with GET statements. After the data has been retrieved with a GET statement you can deblock the data with MOVE or REMAP statements.

In the following example, each disk block contains twelve 40-byte records. Each record contains a 32-byte string, a 4-byte SINGLE number, and a 4-byte LONG integer. After each GET operation, the FOR...NEXT loop uses the REMAP statement to redefine the position of the variables in the record. At the end of the file, the program closes the file. See Chapter 9 and the *VAX BASIC Reference Manual* for more information on the MAP, MAP DYNAMIC, and REMAP statements.

Example

```
MAP (SAM) FILL$ = 512
MAP DYNAMIC (SAM) STRING PRT_ID, SINGLE MAFLD, LONG ADIR_OLDN
OPEN "DUA1:" FOR INPUT AS FILE #2%, SEQUENTIAL FIXED, &
            ACCESS READ, MAP SAM
WHEN ERROR USE err_hand
WHILE 1% = 1%
     GET #2%
     FOR I% = 0% TO 11%
         REMAP (SAM) STRING FILL(I% * 40%), PRT_ID = 32, MAFLD, ADIR_OLDN
         PRINT PRT_ID, MAFLD, ADIR_OLDN
     NEXT I%
NEXT
END WHEN
HANDLER err_hand
  IF ERR <> 11%
    THEN
      EXIT HANDLER
  END IF
END HANDLER
CLOSE #2%
END
```

20.4 I/O to Mailboxes

A mailbox is a record I/O device that passes data from one process to another. You can use a valid mailbox name as a file name, and treat that mailbox as a normal record file. You must have TMPMBX or PRMMBX privilege to create mailboxes. Mailboxes are created and deleted by system services. For more information on using system services in VAX BASIC programs, see Chapter 21 in this manual.

Use the EXTERNAL statement to define the SYS$CREMBX system service that creates the mailbox. In VAX BASIC programs, you create mailboxes by invoking SYS$CREMBX as a function passing either a channel argument and a string literal or a logical name for the mailbox. For example:

```
EXTERNAL INTEGER FUNCTION SYS$CREMBX
SYS$STATUS% = SYS$CREMBX(,CHAN%,,,,,"CONFIRMATION_MBX")
```

If you supply a logical name for the mailbox, be sure that it is in uppercase letters. Once you create the mailbox, you can use it as a logical file name.

The following two examples, when executed on two separate processes, allow you to send and receive data from one process to another.

Example 1

```
DECLARE STRING passenger_name, Confirm_msg
OPEN "CONFIRMATION_MBX" AS FILE #1%
INPUT "WHAT IS THE PASSENGER NAME"; passenger_name
PRINT #1%, passenger_name
LINPUT #1%, confirm_msg
PRINT confirm_msg
END
```

Example 2

```
MAP (res) STRING passenger_name = 32%
DECLARE WORD mbx_chan, LONG sys_status
EXTERNAL LONG FUNCTION sys$crembx (LONG, WORD, LONG, LONG,    &
                                   LONG, LONG, STRING)
WHEN ERROR USE err_trap
sys_status = sys$crembx ( ,mbx_chan,,,,,"CONFIRMATION_MBX")
OPEN "CONFIRMATION_MBX" FOR INPUT AS FILE #1%
LINPUT #1%, passenger_name
OPEN "RESER.LST" FOR INPUT AS FILE #2%,           &
        ORGANIZATION INDEXED, MAP RES, ACCESS READ    &
        PRIMARY passenger_name
FIND #2%, KEY #0% EQ passenger_name
RECEIVING.MSG$ = "Passenger reservation confirmed"
PRINT #1%, RECEIVING.MSG$
END WHEN
HANDLER err_trap
    IF (ERR = 155)
       THEN
       RECEIVING.MSG$ = "Reservation does not exist"
       ELSE
       EXIT HANDLER
    END IF
END HANDLER
CLOSE #2%, #1%
END PROGRAM
```

Example 1 requests a passenger name and sends it to the mailbox. Example 2 looks up the name in an indexed file. If the passenger name exists, Example 2 writes the confirmation message to the mailbox. If the passenger name does not exist, the error handler writes an alternate message. Example 1 then reads the mailbox and returns the result.

VAX BASIC treats the mailbox as a sequential file. You write to the file with the PRINT # or PUT statement, and read it with the INPUT #, LINPUT #, or GET statement.

When either program closes the mailbox, the other program receives an end-of-file error message when it attempts to read the mailbox.

NOTE

All mailbox operations are synchronous. Control does not pass back from a mailbox operation, such as a PUT, to your program until the other program completes the corresponding operation, such as a GET.

20.5 Network I/O

If your system supports DECnet–VAX facilities, and your computer is one of the nodes in a DECnet–VAX network, you can communicate with other nodes in the network with VAX BASIC program statements. VAX BASIC lets you do the following:

- Read and write files on a remote node as you do files on your own system (remote file access)
- Exchange data with a process executing at a remote location (task-to-task communication)

20.5.1 Remote File Access

To write or read files at a remote site, include the node name as part of the file specification. For example:

```
OPEN "WESTON::DUA1:[HOLT]TEST.DAT;2" FOR INPUT AS FILE #2%
```

You can also assign a logical name to the file specification, and use that logical name in all file I/O.

NOTE

You need NETMBX privileges to access files at a remote node.

If the account at the remote site requires a username and password, include this *access string* in the file specification. You do this by enclosing the access string in quotation marks and placing it between the node name and the double colon. For example, the following file specification accesses the account [HOLT.TMP] on node WESTON by giving the username HOLT and the password PASWRD. After accessing the file, your VAX BASIC program can read and write records as if the file were in your account.

```
OPEN 'WESTON"HOLT PASWRD"::DUA0:[HOLT.TMP]INDEXU.DAT;4' &
        FOR INPUT AS FILE #1%, INDEXED, PRIMARY TEXT$
```

Do not use the CONNECT clause when opening a file on a remote node or VAX BASIC will signal the error "Cannot open file" (ERR=162).

20.5.2 Task-to-Task Communication

VAX BASIC supports task-to-task communication if your account has NETMBX privileges.

Follow these steps for task-to-task communication:

1. Establish a command file at the remote site to execute the program you want. The program must be in executable image format. For example, you can create the file MARG.COM at the remote site. MARG.COM contains a line to run an image (in this case, COPYT.EXE).

   ```
   $ RUN COPYT
   ```

   The OPEN statements in the programs at both nodes must specify the same file attributes.

2. Start task-to-task communication by accessing the command file at the remote site. For example, a program at the local node could contain the following line:

   ```
   OPEN 'WESTON::"TASK = MARG"' AS FILE #1%, SEQUENTIAL
   ```

3. The system then assigns the logical name SYS$NET to the program at the local node. At the remote node, the program (COPYT.EXE) must use this logical for all operations. For example:

   ```
   OPEN 'SYS$NET' FOR INPUT AS FILE #1%, SEQUENTIAL
   ```

4. The two programs can then exchange messages. The programs must have a complementary series of send/receive statements.

Example

```
!Local Program
MAP (SJK) MSG$ = 32%
OPEN 'WESTON"DAVIS PSWRD"::"TASK = MARG"' &
        FOR OUTPUT AS FILE #1%, SEQUENTIAL, MAP SJK
LINPUT "WHAT IS THE CUSTOMER NAME"; MSG$
PUT #1%
GET #1%
PRINT MSG$
CLOSE #1%
END

!Remote Node Program
    .
    .
    .
10    MAP (SJK) MSG$ = 32%
      MAP (FIL) NAME$ = 32%, RESERVATION$ = 64%
      OPEN 'SYS$NET' FOR INPUT AS FILE #1%, SEQUENTIAL, &
             MAP SJK
      OPEN 'RESER.DAT'FOR INPUT AS FILE #2%,  &
               INDEXED FIXED, PRIMARY NAME$, MAP FIL
      GET #1%
      MSG$ = "NAME CONFIRMED"
      WHEN ERROR IN
100   FIND #2%, KEY 0% EQ MSG$
      USE
         IF ERR = 153
           THEN
              MSG$ = "ERROR IN NAME"
           ELSE
              EXIT HANDLER
         END IF
      END WHEN

      PUT #1%
    .
    .
    .
      CLOSE #2%, 1%
      END
```

The task-to-task communication ends when the files are closed.

See the *VMS Networking Manual* and the *Guide to Maintaining a VMS System* for more information.

20.5.3 Accessing an Rdb/VMS Database

If you have purchased a VAX Rdb/VMS development license, you can store and access data in a VAX Rdb/VMS database from a VAX BASIC program. To do this, you embed RDO statements in your VAX BASIC program. Each line of an RDO statement must be preceded by the Rdb/VMS statement flag (&RDB&). VAX BASIC line numbers cannot be included in any RDO

statement line. You then precompile your program with the Rdb/VMS precompiler. The precompiler translates the RDO statements into BASIC statements that make direct calls to Rdb/VMS.

Chapter 21

Using VAX BASIC in the Common Language Environment

The VAX BASIC compiler lets you call external routines from a VAX BASIC program. This chapter shows you how to call the following from VAX BASIC:

- External routines written in other VAX languages
- VMS Run-Time Library routines
- VMS system services

The terms routine, procedure, and function are used throughout this chapter. A *routine* is a closed, ordered set of instructions that performs one or more specific tasks. Every routine has an entry point (the routine name), and may or may not have an argument list. Procedures and functions are specific types of routines: a *procedure* is a routine that does not return a value, while a *function* is a routine that returns a value by assigning that value to the function's identifier.

System routines are prewritten VMS routines that perform common tasks such as finding the square root of a number or allocating virtual memory. You can call any system routine from VAX BASIC provided that the data structures necessary for that routine are supported. The system routines used most often are VMS Run-Time Library routines and system services. System routines, which are discussed later in this chapter, are documented in detail in the *VMS Run-Time Library Routines Volume* and the *VMS System Services Reference Manual.*

21.1 Specifying Parameter-Passing Mechanisms

When you pass data between routines that are not written in the same VAX language, you have to specify how you want that data to be represented and interpreted. You do this by specifying a *parameter-passing mechanism*. The three general parameter-passing mechanisms and their keywords in VAX BASIC are as follows:

- By reference—BY REF
- By descriptor—BY DESC
- By value—BY VALUE

The following sections outline each of these parameter-passing mechanisms in more detail.

21.1.1 Passing Parameters by Reference

When you pass a parameter by reference, VAX BASIC passes the address at which the actual parameter value is stored. In other words, your routine has access to the parameter's storage address; therefore, you can manipulate and change the value of this parameter. Any changes that you make to the value of the parameter in your routine are reflected in the calling routine as well.

21.1.2 Passing Parameters by Descriptor

A *descriptor* is a data structure that contains the address of a parameter, along with other information such as the parameter's data type and size. When you pass a parameter by descriptor, the VAX BASIC compiler passes the address of a descriptor to the called routine. You usually use descriptors to pass parameters that have unknown lengths, such as the following:

- Character strings
- Arrays
- Compound data structures

Like parameters passed by reference, any change made to the value of a parameter passed by descriptor is reflected in the calling routine.

21.1.3 Passing Parameters by Value

When you pass a parameter by value, you pass a copy of the parameter value to the routine instead of passing its address. Because the actual value of the parameter is passed, the routine does not have access to the storage location of the parameter; therefore, any changes that you make to the parameter value in the routine do not affect the value of that parameter in the calling routine.

21.1.4 VAX BASIC Default Parameter-Passing Mechanisms

There are default parameter-passing mechanisms established for every data type you can use with VAX BASIC. Table 21–1 shows which VAX BASIC data types you can use with each parameter-passing mechanism.

Table 21–1: Valid Parameter-Passing Mechanisms

Parameter	BY VALUE	BY REF	BY DESC
Integer and Real Data			
Variables	Yes	Yes[1]	Yes
Constants	Yes	Local copy[1]	Local copy
Expressions	Yes	Local copy[1]	Local copy
Elements of a nonvirtual array	Yes	Yes[1]	Yes
Virtual array elements	Yes	Local copy[1]	Local copy
Nonvirtual entire array	No	Yes	Yes[1]
Virtual entire array	No	No	No
Packed Decimal Data			
Variables	No	Yes[1]	Yes

[1]Specifies the default parameter-passing mechanism.

(continued on next page)

Table 21–1 (Cont.): Valid Parameter-Passing Mechanisms

Parameter	BY VALUE	BY REF	BY DESC
Packed Decimal Data			
Constants	No	Local copy[1]	Local copy
Expressions	No	Local copy[1]	Local copy
Nonvirtual array elements	No	Yes[1]	Yes
Virtual array elements	No	Local copy[1]	Local copy
Nonvirtual entire arrays	No	Yes	Yes[1]
Virtual entire arrays	No	No	No
String Data			
Variables	No	Yes	Yes[1]
Constants	No	Local copy	Local copy[1]
Expressions	No	Local copy	Local copy[1]
Nonvirtual array elements	No	Yes	Yes[1]
Virtual array elements	No	Local copy	Local copy[1]
Nonvirtual entire arrays	No	Yes	Yes[1]
Virtual entire arrays	No	No	No
Other Parameters			
RECORD variables	No	Yes[1]	No
RFA variables	No	Yes[1]	No

[1]Specifies the default parameter-passing mechanism.

21.1.5 Creating Local Copies

If a parameter is an expression, function, or virtual array element, then it is not possible to pass the parameter's address. In these cases, VAX BASIC makes a local copy of the parameter's value and passes this local copy by reference.

You can force VAX BASIC to make a local copy of any parameter by enclosing the parameter in parentheses. Forcing VAX BASIC to make a local copy is a useful technique because you make it impossible for the subprogram to modify the actual parameter. In the following example, when variable *A* is printed in the main program, the value is zero because the variable *A* is not modifiable by the subprogram.

Example

```
DECLARE LONG A
CALL SUB1 ((A))
PRINT A
END

SUB SUB1 (LONG B)
B = 3
END SUB
```

Output

```
 0
```

By removing the extra parentheses from *A*, you allow the subprogram to modify the parameter.

Example

```
DECLARE LONG A
CALL SUB1 (A)
PRINT A
END

SUB SUB1 (LONG B)
B = 3
END SUB
```

Output

```
 3
```

21.2 Calling External Routines

Most of the steps of calling external routines are the same whether you are calling an external routine written in VAX BASIC, an external routine written in some other VAX language, a system service, or a VMS Run-Time Library routine. The following sections outline the procedure for calling non-BASIC external routines. For information on calling BASIC routines, see Chapter 14.

21.2.1 Determining the Type of Call

Before you call an external routine, you must determine whether the call to the routine should be a function call or a procedure call. You should call a routine as a function if it returns any type of value. If the routine does not return a value, you should call it as a procedure.

21.2.2 Declaring an External Routine and Its Arguments

To call an external routine or system routine you need to declare it as an external procedure or function and to declare the names, data types, and passing mechanisms for the arguments. Arguments can be either required or optional.

You should include the following information in a routine declaration:

- The name of the external routine
- The data types of all the routine parameters
- The passing mechanisms for all the routine parameters, provided that the routine is not written in VAX BASIC

When you declare an external routine, use the EXTERNAL statement. This allows you to specify the data types and parameter-passing mechanisms only once.

In the following example, the EXTERNAL statement declares *cobsub* as an external subprogram with two parameters—a LONG integer and a string both passed by reference:

```
EXTERNAL SUB cobsub (LONG BY REF, STRING BY REF)
```

With the EXTERNAL statement, VAX BASIC allows you to specify that particular parameters do not have to conform to specific data types and that all parameters past a certain point are optional. A parameter declared as ANY indicates that any data type can appear in the parameter position. In the following example, the EXTERNAL statement declares a SUB subprogram named *allocate*. This subprogram has three parameters: one LONG integer, and two that can be of any VAX BASIC data type.

```
EXTERNAL SUB allocate(LONG, ANY,)
```

A parameter declared as OPTIONAL indicates that all following parameters are optional. You can have both required and optional parameters. The required parameters, however, must appear before the OPTIONAL keyword because all parameters following it are considered optional.

In the following example, the EXTERNAL statement declares the Run-Time Library routine LIB$LOOKUP_KEY. The keyword OPTIONAL is specified to indicate that the last three parameters can be optional.

```
EXTERNAL LONG FUNCTION LIB$LOOKUP_KEY(STRING, LONG, OPTIONAL LONG, STRING, INTEGER)
```

For more information on using the EXTERNAL statement, see the *VAX BASIC Reference Manual.*

21.2.3 Calling the Routine

Once you have declared an external routine, you can invoke it. To invoke a procedure, you use the CALL statement. To invoke a function, you use the function name in an expression. You must specify the name of the routine being invoked and all parameters required for that routine. Make sure the data types and passing mechanisms for the actual parameters you are passing match those you declared earlier, and those declared in the routine.

If you do not want to specify a value for a required parameter, you can pass a null argument by inserting a comma as a placeholder in the argument list. If you are passing a parameter using a mechanism other than the default passing mechanism for that data type, you must specify the passing mechanism in the CALL statement or the function invocation.

The following example shows you how to call the external subprogram *allocate* declared in Section 21.2.2. When *allocate* is called, it is called as a procedure. The first parameter must always be a valid LONG INTEGER value; the second and third parameters can be of any valid VAX BASIC data type.

```
EXTERNAL SUB allocate(LONG, ANY,)
    .
    .
    .
CALL allocate (entity%, a$, 1%)
```

This next example shows you how to call the Run-Time Library routine LIB$LOOKUP_KEY declared in Section 21.2.2. When the routine LIB$LOOKUP_KEY is called, it is invoked as a function. The first two parameters are required; all remaining parameters are optional.

```
EXTERNAL LONG FUNCTION LIB$LOOKUP_KEY(STRING, LONG, OPTIONAL LONG, STRING, INTEGER)
    .
    .
    .
ret_status% = LIB$LOOKUP_KEY(value$, point%)
```

Note that if the actual parameter's data type in the CALL statement does not match that specified in the EXTERNAL statement, VAX BASIC reports the compile-time informational message "Mode for parameter of routine changed to match declaration". This tells you that VAX BASIC has made a local copy of the value of the parameter, and that this local copy has the data type specified in the EXTERNAL declaration. VAX BASIC warns you of this because the change means that the parameter can no longer be modified by the subprogram. If VAX BASIC cannot convert the data type, VAX BASIC signals the error "Mode for parameter of routine not as declared".

The routine being called receives control, executes, and then returns control to the calling routine at the next statement after the CALL statement or function invocation.

VAX BASIC provides the built-in function LOC to allow you to access the address of a named external function. This is especially useful when passing the address of a callback or AST routine to an external subprogram. In the following example, the address of the function *compare* is passed to the subprogram *come_back_now* using the LOC function:

```
EXTERNAL LONG FUNCTION compare (LONG, LONG)
EXTERNAL SUB come_back_now (LONG BY VALUE)
CALL come_back_now (LOC(compare) BY VALUE)
```

21.3 Calling VAX BASIC Subprograms from Other Languages

When you call a VAX BASIC subprogram from another language, there are some additional considerations that you should be aware of. For instance, although VAX BASIC conforms to the VAX Procedure Calling Standard, you should specify explicit passing mechanisms when calling a routine written

in another language. The default passing mechanisms of VAX BASIC may not match what the procedure expects.

VAX FORTRAN passes and receives numeric data by reference; only the default parameter-passing mechanisms are required for passing numeric data back and forth between VAX FORTRAN and VAX BASIC programs.

Both VAX BASIC and VAX FORTRAN pass strings by descriptor. However, VAX FORTRAN subprograms cannot change the length of strings passed to them. Therefore, if you pass a string to a VAX FORTRAN subprogram, you must make sure that the string is long enough to receive the result. You do this in one of two ways:

- *Preextend* the string. Set the string variable equal to SPACE$*(n)*, where *n* is large enough to receive the result.
- Define the string as fixed-length. Name the string in a COMMON or MAP statement.

Because the length of the returned string does not change, it is either padded with spaces or truncated.

To pass an array to a VAX FORTRAN subprogram, you must specify BY REF.

Note that VAX FORTRAN arrays are one-based, while VAX BASIC arrays are zero-based by default. For example, in VAX FORTRAN the array *Two_D*(5,3) represents a 5 by 3 matrix, while in VAX BASIC the array *Two_d*(5,3) represents a 6 by 4 matrix. You can adjust your array bounds in VAX BASIC by using the keyword TO when defining the array bounds. For more information on array bounds, see Chapter 8.

When passing 2-dimensional arrays as parameters, keep in mind that VAX FORTRAN addresses array elements in column major order, while VAX BASIC refers to array elements in row major order. That is, VAX FORTRAN arrays are of the form *Fortran_array*(column,row), while VAX BASIC array elements are addressed as *Basic_array*(row,column). The VAX FORTRAN array *Grid*(x,y) is therefore referred to as *GRID*(y,x) in VAX BASIC. You should reverse references to array elements when passing arrays between VAX BASIC and VAX FORTRAN program modules. You can do this in one of two ways:

- Reverse array bounds in parameter lists
- Switch row and column variables within loops in your program module

Example 21–1 shows a VAX BASIC program that passes a 2-dimensional array to a VAX FORTRAN subprogram, shown in Example 21–2.

Example 21–1: VAX BASIC Main Program

```
PROGRAM call_fortran
    ! The VAX BASIC main program prints the array before
    ! calling the subroutine
        EXTERNAL SUB forsub (WORD DIM(,) BY REF)
        DIM WORD array_x(1 TO 10, 1 TO 5)
        FOR column = 1 TO 5
            FOR row = 1 TO 10
                array_x(row,column)=(10*row + column)
                PRINT array_x(row,column);
            NEXT row
            PRINT
        NEXT column
        PRINT

        CALL forsub(array_x(,) BY REF)

END PROGRAM
```

Example 21–2: VAX FORTRAN Subprogram

```
C       The FORTRAN subprogram receives
C       and then prints the same array

        SUBROUTINE forsub(f_array)
        INTEGER*2 f_array(5,10)
        DO 20 row = 1,5
            TYPE *, (f_array(row,column), column = 1,10)
20      CONTINUE
        RETURN
        END
```

You can pass only the data types that VAX BASIC and VAX FORTRAN have in common. You cannot pass a complex number from a VAX FORTRAN program to a VAX BASIC program, because VAX BASIC does not support complex numbers. However, you can pass a complex number as two floating-point numbers and treat them independently in the VAX BASIC program.

21.4 Calling System Routines

The steps for calling system routines are the same as those for calling any external routine. However, when calling system routines, you need to provide additional information, which is discussed in the following sections.

21.4.1 VMS Run-Time Library Routines

The VMS Run-Time Library routines are grouped according to the types of tasks they perform. The routines in each group have a prefix that identifies them as members of a particular VMS Run-Time Library facility. Table 21–2 lists all the language-independent Run-Time Library facility prefixes and the types of tasks each facility performs.

Table 21–2: Run-Time Library Facilities

Facility Prefix	Types of Tasks Performed
DTK$	DECtalk routines that are used to control the DIGITAL DECtalk device
LIB$	General purpose routines that obtain records from devices, manipulate strings, convert data types for I/O, allocate resources, obtain system information, signal exceptions, establish condition handlers, enable detection of hardware exceptions, and process cross-reference data
MTH$	Mathematics routines that perform arithmetic, algebraic, and trigonometric calculations
OTS$	Language-independent support routines that perform tasks such as data type conversions as part of a compiler's generated code
PPL$	Parallel processing routines that help you implement concurrent programs on single-CPU and multiprocessor systems
SMG$	Screen management routines that are used in designing, composing, and keeping track of complex images on a video screen
STR$	String manipulation routines that perform such tasks as searching for substrings, concatenating strings, and prefixing and appending strings

21.4.2 System Service Routines

System services are system routines that perform a variety of tasks such as controlling processes, communicating among processes, and coordinating I/O.

Unlike the VMS Run-Time Library routines, which are divided into groups by facility, all system services share the same facility prefix (SYS$). However, these services are logically divided into groups that perform similar tasks. Table 21–3 describes these groups.

Table 21–3: System Services

Group	Types of Tasks Performed
AST	Allows processes to control the handling of ASTs
Change Mode	Changes the access mode of particular routines
Condition Handling	Designates condition handlers for special purposes
Event Flag	Clears, sets, reads, and waits for event flags, and associates with event flag clusters
Information	Returns information about the system, queues, jobs, processes, locks, and devices
Input/Output	Performs I/O directly, without going through VAX RMS
Lock Management	Enables processes to coordinate access to shareable system resources
Logical Names	Provides methods of accessing and maintaining pairs of character string logical names and equivalence names
Memory Management	Increases or decreases available virtual memory, controls paging and swapping, and creates and accesses shareable files of code or data
Process Control	Creates, deletes, and controls execution of processes
Security	Enhances the security of VMS systems
Time and Timing	Schedules events, and obtains and formats binary time values

21.4.3 System Routine Arguments

All of the system routine arguments are described in terms of the following information:

- VMS usage
- Data type

- Type of access allowed
- Passing mechanism

VMS usages are data structures that are layered on the standard VMS data types. For example, the VMS usage *mask_longword* signifies an unsigned longword integer that is used as a bit mask, and the VMS usage *floating_point* represents any VMS floating-point data type. Table 21–4 lists all the VMS usages and the VAX BASIC statements you need to implement them.

Table 21–4: VMS Usages

VMS Usage	VAX BASIC Implementation
access_bit_names	Not applicable (NA)
access_mode	BYTE (signed)
address	LONG

address_range	LONG address_range (1)
	or
	RECORD address_range
	    LONG beginning_address
	    LONG ending_address
	END RECORD

arg_list	NA
ast_procedure	EXTERNAL LONG FUNCTION ast_proc [1]
boolean	LONG
byte_signed	BYTE
byte_unsigned	BYTE [2]
channel	WORD
char_string	STRING

complex_number	RECORD complex
	    REAL real_part
	    REAL imaginary_part
	END RECORD

[1]Use the LOC function to pass the address of an AST routine to a system service. Specify BY VALUE for the passing mechanism.

[2]Although unsigned data structures are not directly supported in VAX BASIC, you can substitute the signed equivalent provided you do not exceed the range of the signed data structure.

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Table 21–4 (Cont.): VMS Usages

VMS Usage	VAX BASIC Implementation
cond_value	LONG
context	LONG
date_time	BASIC$QUADWORD [3]
device_name	STRING
ef_cluster_name	STRING
ef_number	LONG
exit_handler_block	RECORD EHCB LONG flink LONG handler_addr BYTE arg_count BYTE FILL(3) LONG status_value_addr END RECORD
fab	NA
file_protection	LONG
floating_point	SINGLE DOUBLE GFLOAT HFLOAT
function_code	RECORD function-code WORD major-function WORD subfunction END RECORD
identifier	LONG
io_status_block	RECORD iosb WORD iosb_field(1 to 4) END RECORD

[3]The definition of the RECORD structures are included in the VAX BASIC system definitions text library. See Section 21.4.4 for more information.

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Table 21–4 (Cont.): VMS Usages

VMS Usage	VAX BASIC Implementation

item_list_2	RECORD item_list_two
	        GROUP item(15)
	           VARIANT
	           CASE
	              WORD comp_length
	              WORD code
	              LONG comp_address
	           CASE
	              LONG terminator
	           END VARIANT
	        END GROUP
	END RECORD

item_list_3	RECORD item_list_3
	        GROUP item (15)
	           VARIANT
	           CASE
	              WORD buf_len
	              WORD code
	              LONG buffer_address
	              LONG length_address
	           CASE
	              LONG terminator
	           END VARIANT
	        END GROUP
	END RECORD

item_list_pair	RECORD item_list_pair
	        GROUP item(15)
	           VARIANT
	           CASE
	              LONG code
	              LONG item_value
	           CASE
	              LONG terminator
	           END VARIANT
	        END GROUP
	END RECORD item_list_pair

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Table 21–4 (Cont.): VMS Usages

VMS Usage	VAX BASIC Implementation
item_quota_list	RECORD item_quota_list GROUP quota(n) VARIANT CASE BYTE quota_name LONG item_value CASE BYTE list_end END VARIANT END GROUP END RECORD
lock_id	LONG
lock_status_block	NA
lock_value_block	NA
logical_name	STRING
longword_signed	LONG
longword_unsigned	LONG [2]
mask_byte	BYTE
mask_longword	LONG
mask_quadword	BASIC$QUADWORD [3]
mask_word	WORD
null_arg	A null argument is indicated by a comma used as a placekeeper in the argument list.
octaword_signed	BASIC$OCTAWORD
octaword_unsigned	BASIC$OCTAWORD
page_protection	LONG
procedure	EXTERNAL LONG FUNCTION proc
process_id	LONG
process_name	STRING

[2]Although unsigned data structures are not directly supported in VAX BASIC, you can substitute the signed equivalent provided you do not exceed the range of the signed data structure.
[3]The definition of the RECORD structures are included in the VAX BASIC system definitions text library. See Section 21.4.4 for more information.

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Table 21–4 (Cont.): VMS Usages

VMS Usage	VAX BASIC Implementation
quadword_signed	BASIC$QUADWORD [3]
quadword_unsigned	BASIC$QUADWORD [3]
rights_holder	BASIC$QUADWORD [3]
rights_id	LONG
rab	NA
section_id	BASIC$QUADWORD [3]
section_name	STRING
system_access_id	BASIC$QUADWORD [3]
time_name	STRING
uic	LONG
user_arg	LONG
varying_arg	Dependent upon application.
vector_byte_signed	BYTE array(n)
vector_byte_unsigned	BYTE array(n) [2]
vector_longword_signed	LONG array(n)
vector_longword_unsigned	LONG array(n) [2]
vector_quadword_signed	NA
vector_quadword_unsigned	NA
vector_word_signed	WORD array(n)
vector_word_unsigned	WORD array(n) [2]
word_signed	WORD
word_unsigned	WORD [2]

[2]Although unsigned data structures are not directly supported in VAX BASIC, you can substitute the signed equivalent provided you do not exceed the range of the signed data structure.
[3]The definition of the RECORD structures are included in the VAX BASIC system definitions text library. See Section 21.4.4 for more information.

If a system routine argument is optional, it will be indicated in the format section of the routine description in one of two ways:

```
[,optional-argument]
,[optional-argument]
```

If the comma appears outside the brackets, you must either pass a zero by value or use a comma in the argument list as a placeholder to indicate the place of the omitted argument. If this is the last argument in the list, you must still include the comma as a placeholder. If the comma appears inside the brackets, you can omit the argument altogether as long as it is the last argument in the list.

21.4.4 Including Symbolic Definitions

To enhance program development, VAX BASIC allows you to use symbolic definitions. Symbolic definitions are names or symbols associated with values. These symbols are used in many ways; the value associated with a symbol can be a status code, a mask, or an offset into a data structure. Many system routines depend on values that are defined in separate symbol definition files. For example, the status code for successful completion has a value of one. However, this code for successful completion is defined in the system library (STARLET) as the symbol SS$_NORMAL.

A program might compare the status code returned by a system service to either the symbolic constant SS$_NORMAL or the integer value one. The program would execute the same way in either case. In the first case, the value for SS$_NORMAL is supplied at link time by the VMS Linker. In the second case, the value 1 is included in the program as a literal constant. The advantages of using symbolic definitions are as follows:

- Because symbolic definition names are mnemonic, the program is easier to read and understand.
- It is easier to write the symbolic definition and let the VMS Linker fill in the value, than to look up the value associated with the symbol and include that value in the program.
- Should the value associated with a symbol ever change, you must relink the program. To change a hard-coded definition, you must edit the source file, then recompile and relink.

Symbolic definitions used by system services are located in the default system library, STARLET.OLB.

For Run-Time Library routines, the only time that you need to include symbolic definitions is when you are calling an SMG$ routine, or when you are calling a routine that is a jacket to a system service. (A jacket routine in the Run-Time Library is a routine that provides a simpler, more easily used interface to a system service.) If you call a routine in the SMG$ facility, you must include the definition file SMGDEF. All system services, however,

require that you include SSDEF to check status. Many other system services require other symbol definitions as well.

To determine whether or not you need to include other symbolic definitions for the system service you want to reference, refer to the documentation for that service. If the documentation states that values are defined in the specified macro, you must include those symbolic definitions in your program. VAX BASIC provides a text library that contains symbolic definitions that can be accessed using the %INCLUDE directive. In the following example, the definition file, SMGDEF is included from the text library SYS$LIBRARY:BASIC$STARLET.TLB:

```
%INCLUDE "SMGDEF" %FROM %LIBRARY "SYS$LIBRARY:BASIC$STARLET.TLB"
```

For more information on including text libraries, see Chapter 18.

21.4.5 Condition Values

Many system routines return a condition value that indicates success or failure. If a condition value is returned, you should check this value after you call a system routine and control returns to your program.

Condition values indicating success always appear first in the list of condition values for a particular routine, and success codes always have odd values. A success code that is common to many system routines is the condition value SS$_NORMAL, which indicates that the routine completed normally and successfully. You can test for this condition value as follows:

```
ret_status = SMG$CREATE_PASTEBOARD(pb_id)
IF (ret_status <> SS$_NORMAL) THEN
   CALL LIB$STOP(ret_status BY VALUE)
END IF
```

Because all success codes have odd values, you can check a return status for any success code. For example, you can cause execution to continue only if a success code is returned by including the following statements in your program:

```
ret_status = SMG$CREATE_PASTEBOARD(pb_id)
IF (ret_status AND 1%) = 0% THEN
   CALL LIB$STOP(ret_status BY VALUE)
END IF
```

In general, you can check for a particular success or failure code or you can test the condition value returned against all success codes or all failure codes.

21.5 Examples of Calling System Routines

This section provides complete examples of calling system routines from VAX BASIC. In addition to the examples provided here, the *VMS Run-Time Library Routines Volume* and the *VMS System Services Reference Manual* also provide examples for selected routines. Refer to these manuals for help on the use of a specific system routine.

Example 21–3 uses a function that invokes the SYS$TRNLNM system service. SYS$TRNLNM translates a logical name to an equivalence name. It places the equivalence name string into a string variable you supply in the parameter list.

System services never change a string variable's length. Therefore, if you use a system service that returns a string, be sure that the receiving string variable is long enough for the returned data. You can make sure of this in one of two ways:

- Define the string variable's length in a MAP, COMMON or RECORD definition.
- Assign a long string to the variable (for example, A$ = SPACE$(80)). This preextends the variable so that it is long enough to receive all of the returned data.

Example 21–3: Calling System Services

```
10   !This function attempts to translate a logical name while searching
     !through all of the tables defined in LNM$DCL_LOGICAL.  If the translation
     !is successful, $TRNLNM returns the equivalence name string.

     FUNCTION STRING Translate(STRING Logical_name)
     EXTERNAL LONG FUNCTION SYS$TRNLNM (LONG, STRING, STRING, LONG, ITEM_LIST)
     EXTERNAL LONG CONSTANT LNM$M_CASE_BLIND, LNM$_STRING, SS$_NORMAL

     !Declare the parameters
     DECLARE LONG attributes,   &
                  trans_status
     DECLARE WORD equiv_len

     !Declare the value returned by the function.
     DECLARE LONG CONSTANT Buffer_length = 255
     RECORD item_list
     GROUP item (1)
             VARIANT
                  CASE
                     WORD Buf_len
                     WORD Code
                     LONG Buffer_address
                     LONG Length_address
                   CASE
                     LONG Terminator
              END VARIANT
      END GROUP item
      END RECORD item_list
      !Declare an instance of the record

      DECLARE ITEM_LIST TRNLNM_ITEMS

      !Define a common area for Translation_buffer

      COMMON (Trans_buffer) &
              STRING Translation_buffer = Buffer_length

      !Setting TRN$LNM to not distinguish between uppercase and lowercase
      !letters in the logical name to be translated.

      Attributes = LNM$M_CASE_BLIND
      !Assign values to each record item.

      TRNLNM_ITEMS::item(0)::Buf_len = Buffer_length
      TRNLNM_ITEMS::item(0)::Code = LNM$_STRING
      TRNLNM_ITEMS::item(0)::Buffer_address = LOC(Translation_buffer)
      TRNLNM_ITEMS::item(0)::Length_address = LOC(Equiv_len)
      TRNLNM_ITEMS::item(1)::Terminator = 0%

      !Invoke the function

      TRANS_STATUS = SYS$TRNLNM(attributes,"LNM$DCL_LOGICAL", logical_name, &
                                 ,trnlnm_items)
```

(continued on next page)

Example 21–3 (Cont.): Calling System Services

```
        !Check the condition value

        IF trans_status AND SS$_NORMAL
        THEN
                 Translate = LEFT(Translation_buffer, Equiv_len)
        ELSE
                 Translate = ""
        END IF
        END FUNCTION
```

Example 21–4 is a complete program that demonstrates the use of the system service $QIOW. Unlike SYS$QIO, SYS$QIOW performs synchronously; SYS$QIOW returns a condition value to the caller after I/O operation is complete.

Example 21–4: Program Displaying the $QIOW System Service Routine

```
10  !Declare SYS$QIOW as an EXTERNAL FUNCTION

    EXTERNAL LONG FUNCTION SYS$QIOW(,WORD BY VALUE,LONG BY VALUE,WORD DIM() &
                                    BY REF,,,STRING BY REF,LONG BY VALUE,, &
                                    LONG BY VALUE,,)
    !Declare SYS$ASSIGN as an EXTERNAL FUNCTION

    EXTERNAL LONG FUNCTION SYS$ASSIGN(STRING,WORD,,)

    EXTERNAL LONG CONSTANT IO$_WRITEVBLK

    !Declare the parameters

    DECLARE STRING my_term, out_str, &
            WORD term_chan, counter, stat_block(3),&
            LONG ret_status, msg_len, car_cntrl

    out_str = "Successful $QIOW output!"
    my_term = "SYS$COMMAND"
    msg_len = LEN(out_str)
    car_cntrl = 32%
    !Assign a channel to the terminal
    ret_status = SYS$ASSIGN(my_term, term_chan, ,)
    CALL LIB$STOP(ret_status BY VALUE) IF (ret_status AND 1%) = 0%
```

(continued on next page)

Example 21–4 (Cont.): Program Displaying the $QIOW System Service Routine

```
!Output the message four times
FOR counter = 1% to 4%
    ret_status = SYS$QIOW(,term_chan BY VALUE, IO$_WRITEVBLK BY VALUE, &
                          stat_block() BY REF,,,out_str BY REF,        &
                          msg_len BY VALUE,,car_cntrl BY VALUE,,)
    CALL LIB$STOP(ret_status BY VALUE) IF (ret_status AND 1%) = 0%
    CALL LIB$STOP(stat_block(0%) BY VALUE) &
              IF (stat_block(0%) and 1%) = 0%
NEXT counter

END
```

Output

```
Successful $QIOW output!
Successful $QIOW output!
Successful $QIOW output!
Successful $QIOW output!
```

In addition to invoking the function SYS$QIOW, the previous example also invokes the function SYS$ASSIGN. This function provides a process with an I/O channel so that input and output operations can be performed on a logical device name *(my_term)*. As soon as SYS$ASSIGN is invoked and a path is established to the device, a counter is set up to invoke the $QIOW function four times. Once all I/O operations are complete, $QIOW returns to the caller.

21.6 The VAX Procedure Calling and Condition Handling Standard

The primary purpose of the VAX Procedure Calling and Condition Handling Standard is to define the concepts for invoking routines and passing data between them. Some of the interface attributes that the VAX Procedure Calling and Condition Handling Standard specifies are as follows:

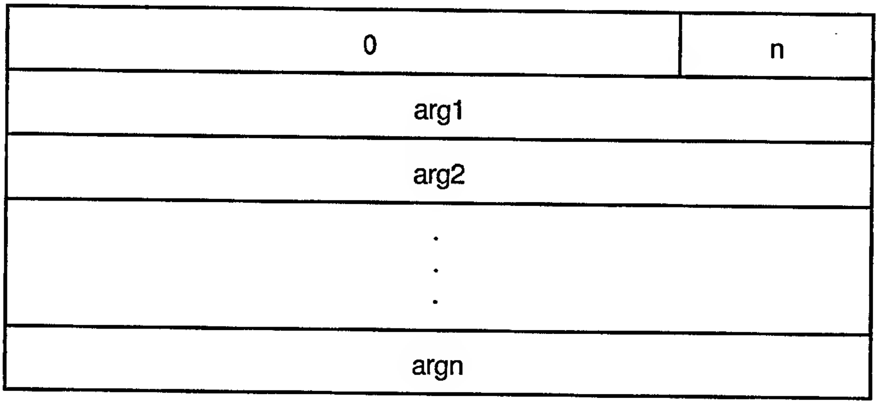
- The argument list
- The return of the function value
- Register usage
- Stack usage

These attributes are examined in more detail in the following sections. The VAX Procedure Calling and Condition Handling Standard also defines such interfaces as the calling sequence, the argument data types and descriptor formats, condition handling, and stack unwinding. These attributes are discussed in detail in the *Introduction to VMS System Routines*.

21.6.1 The Argument List

One of the module interfaces defined by the VAX Procedure Calling and Condition Handling Standard is the *argument list*. You use an argument list to pass information to a routine and receive results. An argument list is a collection of longwords in memory that represents a routine parameter list and possibly includes a function value. Figure 21–1 shows a typical argument list.

Figure 21–1: Structure of a VAX Argument List



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The VMS operating system requires that the first longword be present. This longword stores the number of arguments (the argument count: *n*) as an unsigned integer value in the low byte of the longword. The remaining 24 bits of the first longword are reserved for DIGITAL use and should be zero. The longwords labeled *arg1* through *argn* are the actual parameters, which can be any of the following:

- An uninterpreted 32-bit value (passed by value)

- An address (passed by reference)
- An address of a descriptor (passed by descriptor)

The forms of the arguments in the argument list depend on the passing mechanisms specified. The argument list contains the parameters that are passed to the routine. If, for example, you pass three arguments, the first one by value, the second by reference, and the third by descriptor, the argument list would contain the value of the first argument, the address of the second, and the address of the descriptor of the third. Figure 21–2 illustrates this argument list.

Figure 21–2: Example of a VAX Argument List

0	3
copy of the first parameter	
address of the second parameter	
address of descriptor of the third parameter	

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21.6.2 The Return of the Function Value

A function is a routine that returns a single value to the calling routine. The *function value* represents the return value that is assigned to the function's identifier during execution. According to the VAX Procedure Calling and Condition Handling Standard, a function value can be returned as either an actual value or a condition value that indicates success or failure.

21.6.3 Register and Stack Usage

The VAX Procedure Calling and Condition Handling Standard defines several registers. These registers and their defined uses are listed in Table 21–5.

Table 21–5: VAX Register Usage

Register	Use
PC	Program counter
SP	Stack pointer
FP	Current stack frame pointer
AP	Argument pointer
R1	Environment value (when necessary)
R0, R1	Function value return registers

The called routine can use registers R2 through R11 for computation and the AP register as a temporary register.

The *stack* is a Last-In/First-Out (LIFO) temporary storage area allocated by the system for each user process. On the call stack, the system maintains information about each routine call in the current image. Each time a routine is called by a program, the hardware creates a structure on the call stack known as the *call frame*. The call frame for each active routine contains the following:

- A pointer to the call frame of the previous routine call. This pointer corresponds to the frame pointer (FP).
- The argument pointer (AP) of the previous routine call.
- The storage address of the point at which the routine was called; that is, the address of the instruction following the call to the current routine. This address is called the program counter (PC).
- The contents of other general registers. Based on a mask specified in the control information, the system restores the saved contents of these registers to the calling routine when control returns to it.

When execution of a routine ceases, the system uses the frame pointer in the call frame of the current routine to locate the frame of the previous routine. The system then removes the call frame of the current routine from the stack.

21.7 Additional Information

The information provided on system routines in this chapter is general to all system services and VMS Run-Time Library routines. For specific information on these routines, refer to the *VMS Run-Time Library Routines Volume* and the *VMS System Services Reference Manual*.

For more information on the VAX Procedure Calling and Condition Handling Standard, see the *Introduction to VMS System Routines*. For information on programming considerations with external routines, refer to the *Introduction to VMS System Routines* and the *Guide to Creating VMS Modular Procedures*.

Chapter 22

Libraries and Shareable Images

Libraries and shareable images allow you to access program symbols and incorporate commonly used routines into your source code. This chapter describes how to create and access libraries and shareable images in VAX BASIC.

22.1 Introduction

Libraries are files that can contain object modules, text modules, and shareable images. There are two types of libraries: system-supplied and user-supplied. System-supplied libraries are provided by the VMS system, whereas user-supplied libraries are libraries that you create.

Shareable images are similar to libraries; they contain code that can be shared by other programs. However, shareable images contain executable code rather than object code.

If you have routines that are used in many programs, placing the routines in object module libraries or shareable images lets you access them at link time. You do not need to include the routines in the source code, thus shortening compilation time and conserving disk space.

If you have routines that are used simultaneously by many different programs, placing the routines in installed shareable images can improve performance at run time, conserve main physical memory, and reduce paging I/O because one copy of the executable code is shared by all users.

Object module libraries, shareable image libraries, and shareable images can be accessed in the BASIC environment as well as at DCL command level. When you link programs at DCL command level, these libraries can contain object code created by any VAX native mode compiler or assembler.

When you run a program in the BASIC environment, you can access:

- Object libraries containing only VAX BASIC object code (object code from SUB, FUNCTION, and PICTURE subprograms)
- Shareable image libraries that contain BASIC or non-BASIC object code (such as a transfer vector written in VAX MACRO)

Only BASIC subprograms can be loaded into the environment with the LOAD command.

For a more thorough understanding of libraries and shareable images, refer to the *VMS Linker Utility Manual* and the *Guide to Creating Modular Library Procedures*. See the *VMS Install Utility Manual* for more information on installing shareable images. For information on text libraries, see Chapter 18 in this manual.

22.2 System-Supplied Libraries

If symbols are unresolved after the VMS Linker searches all user-supplied libraries, the linker goes on to search the files in the default system library. VMS supplies the following system libraries:

System Library	Purpose
IMAGELIB.OLB	This library contains the symbol tables for the parts of the VAX Common Run-Time Library (RTL) that are in shareable images. If either the VMS Linker or the VAX BASIC compiler needs to search the default system library, it searches the shareable image symbol table library (IMAGELIB.OLB) first.
STARLET.OLB	This library is an object module library containing the object files used to create the shareable image version of the RTL, as well as other less frequently used procedures. This object library also contains modules for interfacing to VMS System Services. If program symbols remain unresolved after the VMS Linker searches IMAGELIB.OLB, the linker then searches this library.

The linker searches modules in the following order:

1. Modules and libraries specified in the LINK command line, in the order given
2. User-supplied libraries (logicals of the form LNK$LIBRARY and LNK$LIBRARY_1 through LNK$LIBRARY_999)

3. Images contained in IMAGELIB.OLB
4. Modules contained in STARLET.OLB

If the linker finds no needed routines in the RTL shareable images, it does not include any shareable images in the image being created. You can use the /NOSYSSHR qualifier to the LINK command to suppress the linker's search of RTL shareable images. Similarly, you can use the /NOSYSLIB qualifier to suppress the linker's search of both RTL shareable images and STARLET.OLB.

Note that the VMS Linker searches user-supplied libraries before searching the default system library. This means that, if one of your modules has the same name (program symbol) as a VMS System Service or an RTL routine, the VMS Linker will include your module in the resulting image rather than the system service or RTL routine.

22.3 Creating User-Supplied Object Module Libraries

You create a user-supplied object module library with the DCL command LIBRARY. To do this, you must specify a library file specification as well as a list of the program modules you want to insert into the library. For example:

```
$  BASIC MODULE1,MODULE2
$  LIBRARY/CREATE TESTLIB1.OLB MODULE1.OBJ,MODULE2.OBJ
```

The BASIC command creates object files from MODULE1.BAS and MODULE2.BAS. The LIBRARY command creates an object module library named TESTLIB1.OLB and inserts MODULE1.OBJ and MODULE2.OBJ into it. See the *VMS DCL Dictionary* for more information on the LIBRARY command.

22.3.1 Accessing User-Supplied Object Module Libraries in the BASIC Environment

Within the BASIC environment, VAX BASIC allows you to automatically access user-supplied object module libraries containing object files created by VAX BASIC. To do this, you must assign the logical name BASIC$LIB*n* to each library you wish to access, where *n* represents a number from 0 to 9. For example:

```
$  ASSIGN USER$$DEV:[SMITH]TESTLIB.OLB BASIC$LIB0
```

After you enter this command, a program executing in the BASIC environment automatically accesses USER$$DEV:[SMITH]TESTLIB.OLB to resolve program symbols. Note that this command assigns BASIC$LIB0 as a process-wide logical name. A privileged user can also assign a VAX BASIC library as a groupwide or systemwide logical name.

22.3.2 Accessing User-Supplied Object Module Libraries at DCL Level

To access user-supplied object module libraries at DCL level, you must specify the /LIBRARY qualifier to the DCL command LINK. For example:

```
$ LINK MAIN,TESTLIB/LIBRARY
```

This command causes the linker to search TESTLIB.OLB if there are unresolved symbols in the VAX BASIC object module MAIN.OBJ. You can also explicitly include a module from a library with the /INCLUDE qualifier:

```
$ LINK MAIN,TESTLIB/LIBRARY/INCLUDE = (module1,module2)
```

This command causes the VMS Linker to include *module1* and *module2* from TESTLIB.OLB, whether or not it needs these modules to resolve symbols.

As in the BASIC environment, BASIC at DCL level allows you to access user-supplied object module libraries automatically. However, a program executing at DCL level does not automatically search libraries that are assigned to the logical name BASIC$LIB0. Instead, the linker searches libraries that are assigned to the logical name LNK$LIBRARY. If you have more than one library for the linker to search, you must number these libraries consecutively; otherwise, the linker does not search past the first missing logical name. The linker allows you to number libraries from 1 through 999.

For example:

```
$ ASSIGN USER$$DEV:[KELLY]TESTLIB.OLB LNK$LIBRARY
$ ASSIGN USER$$DEV:[KELLY]TESTLIB1.OLB LNK$LIBRARY_1
$ ASSIGN USER$$DEV:[KELLY]TESTLIB2.OLB LNK$LIBRARY_2
```

After you issue these commands, a program executing at DCL level automatically accesses USER$$DEV:[KELLY]TESTLIB.OLB, USER$$DEV:[KELLY]TESTLIB1.OLB, and USER$$DEV:[KELLY]TESTLIB2.OLB to resolve program symbols.

On MicroVMS systems, LNK$LIBRARY_1 is already used by the system; therefore, you should begin your assignments with LNK$LIBRARY_2 and number any additional libraries consecutively. On other VMS systems, number the first library as LNK$LIBRARY, the second as LNK$LIBRARY_1, the third as LNK$LIBRARY_2, and so on.

22.4 Shareable Images

Shareable images are not directly executable. They contain executable code that can be shared by other images and are intended to be included by the VMS Linker in other images. You can access shareable images both in the BASIC environment and at DCL level, as described in the next two sections.

The benefits of using shareable images include:

- Conserving disk storage space
- Conserving main physical memory
- Reducing paging I/O
- Allowing shared memory-resident databases
- Eliminating the need to relink programs that access a new version of a shared routine

Note that some of these benefits can only be realized if the shareable image is installed with the VMS Install Utility (INSTALL).

To create a shareable image, use the /SHAREABLE qualifier to the DCL command LINK. In addition, you must specify at least one object module. For example:

```
$ LINK/SHAREABLE prog1
```

This command creates an image that can be linked to other programs. You cannot execute a shareable image with the DCL command RUN.

When a program is linked with a shareable image, the required shareable image code is not included in the created executable image on disk. This code is included by the image activator at run time. Therefore, many programs can reside on disk and be bound with a particular shareable image, and only one physical copy of that shareable image file needs to exist on disk.

If a shareable image has been installed, you conserve physical memory and potentially reduce paging I/O. In this case, many processes can include the physical memory pages of an installed shareable image in their address space. This reduces the requirements for physical memory.

Paging occurs when a process attempts to access a virtual address that is not in the process working set. When this page fault occurs, the page is either in a disk file, in which case paging I/O is required, or is already in physical memory. If a page fault occurs for a shared page, the shared page may already be resident in memory and in this case, no paging I/O is required.

22.4.1 Accessing Shareable Images in the BASIC Environment

To access a shareable image in the VAX BASIC environment, you must create a shareable image library and place the shareable image you want to use in that library. See Section 22.4.2 for information on creating a shareable image.

You use the DCL command LIBRARY with the /CREATE and /SHARE qualifiers to create a shareable image library. For example:

```
$ LIBRARY/CREATE/SHARE MYLIB PROG1
```

This command creates the shareable image library MYLIB and inserts the shareable image PROG1 in that library.

Once you create a shareable image library, you must assign the library to the logical name BASIC$LIB*n*, where *n* represents a number from 0 to 9. For example:

```
$ ASSIGN DEV$$DISK:[BOB.LIBRARIES]MYLIB BASIC$LIB0
```

Once this command executes, a program executing in the BASIC environment automatically accesses the library MYLIB as a shareable image library to resolve global names.

Any shareable images referenced by the shareable image library must reside in SYS$SHARE or a logical name for the image must specify where the shareable image resides. For example:

```
$ ASSIGN DEV$$DISK:[BOB.IMAGES]PROG1.EXE PROG1
```

22.4.2 Accessing Shareable Images at DCL Level

To access a shareable image at DCL level, you must follow these steps:

1. Write and compile a program unit that is to be inserted into a shareable image.
2. Create an options file required for the link operation.
3. Link the program with the /SHAREABLE qualifier and specify the options file with the /OPTION qualifier.
4. Write a main program that accesses the routine in the shareable image.
5. Compile the main program and link it with the shareable image.

The following example is an illustration of how to access a shareable image at DCL level using these five steps.

Step 1: Write and compile a program unit that is to be inserted into a shareable image.

```
!Program name - ADD.BAS
FUNCTION REAL ADD (LONG A, LONG B)
ADD = A + B
FUNCTIONEND
```

Step 2: Create an options file required for the link operation.

```
!Program name - ADDSUB.OPT
UNIVERSAL = ADD
```

Step 3: Link the program with the qualifiers /SHAREABLE and /OPTION.

```
$  LINK/SHAREABLE ADD, ADDSUB/OPTION
```

Copy the shareable image to SYS$SHARE:, or assign a logical name to the full image file specification.

Step 4: Write a main program that accesses the routine in the shareable image.

```
!Program name - CALLADD.BAS
EXTERNAL REAL FUNCTION ADD (LONG, LONG)
DECLARE LONG X,Y
X = 1
Y = 2
PRINT ADD(X,Y)
END
```

Step 5: Compile the main program and link it with the shareable image.

```
$  LINK CALLADD,ADDMAIN/OPTION
```

In order to link CALLADD with the shareable image ADD, you must have a VMS Linker options file specifying that ADD is a shareable image:

```
!Options file - ADDMAIN.OPT
ADD/SHAREABLE
```

Now you are ready to execute the program. When you do this, the image activator attempts to locate the shareable image in the directory SYS$SHARE:. If you want the image activator to access a shareable image outside SYS$SHARE:, you must assign a logical name to the shareable image before you execute the program. That is, you must assign the full file specification of the shareable image to the name of the shareable image, as follows:

```
$  DEFINE MYSHR DISK$WORKDISK:[MYDIR]MYSHR
```

This is a very simple example of using shareable images. For a thorough understanding of shareable images, see the *VMS Linker Utility Manual*.

Chapter 23

CDD/Plus Support in VAX BASIC

This chapter explains the capabilities of VAX CDD/Plus and how a VAX BASIC user can take advantage of them. This chapter only applies to you if you have CDD/Plus Version 4.0 or higher installed on your system.

23.1 Overview of VAX CDD/Plus

VAX CDD/Plus (CDD/Plus) software is a common data dictionary tool that supports sharing of data definitions by VMS programming languages and VAX Information Architecture products. Each language or product translates the generic definitions stored in VAX CDD/Plus language- or product-specific definitions that it can use.

Because VAX CDD/Plus data definitions can be used by several different products, programmers do not have to write special programs to allow different products to work together or store redundant copies of data files. Also, because VAX CDD/Plus data definitions are centrally located, you can change several programs by modifying a single data definition.

VAX BASIC Version 3.3 and higher supports CDD/Plus Version 4.0 features, which includes dependency recording. Dependency recording allows you to record (or track) what programs use a CDD/Plus data definition. It helps you evaluate the effort needed to change a record definition by identifying the modules that need to be modified, recompiled, or both.

To support dependency recording, CDD/Plus uses a dictionary structure known as CDO-format. (The type of dictionary used in CDD versions prior to Version 4.0 is known as DMU-format.) You can have many CDO-format dictionaries in use on a VMS system (but only one DMU-format dictionary). The two types of dictionaries can coexist on a system and a program can refer to data definitions in both types.

When dependency recording is in effect, the VAX BASIC compiler updates the CDO-format dictionary to show what dictionary entities the program uses. A dictionary entity is any object stored in a CDD/Plus dictionary, such as a data definition or form definition.

In addition to supporting the functionality of the DMU-format dictionary, a CDO-format dictionary allows many additional capabilities that are useful to VAX BASIC applications. Using CDD/Plus gives BASIC users the following capabilities:

- Defining and managing data definitions using the CDO utility
- Reading existing DMU-format dictionaries from CDO
- Referring to CDO-format dictionaries distributed over multiple nodes in the network
- Creating, accessing, and controlling data definitions at the field definition level
- Forming relationships between CDO dictionary definitions, possibly connecting definitions from multiple nodes in the network
- Tracking the use of dictionary-defined information
- Querying CDD/Plus to learn what relationships exist

When you compile a program that contains references to data definitions in a DMU-format dictionary, the data definitions are included in your program, but the DMU-format dictionary cannot be updated to show that the program uses those data definitions and depends on their continued integrity. CDO-format dictionaries offer the additional capability of recording dependency relationships between programs and the dictionary entities that they use.

23.2 CDD/Plus Concepts

This section introduces CDD/Plus concepts.

23.2.1 Dictionary Formats

CDD/Plus allows two types of dictionaries:

- The DMU-format dictionary

  You create and manipulate a DMU-format dictionary using the DMU, CDDL, and CDDV utilities. This type of dictionary was the only format available prior to Version 4.0 of CDD/Plus.

- The CDO-format dictionary

  You create and manipulate a CDO-format dictionary using the CDO utility and the CDD/Plus Call Interface. Some of the advantages of CDO-format dictionaries have been mentioned previously and will be clarified in later sections.

These two types of dictionaries can coexist on a system to form one logical directory structure. CDD/Plus uses a special dictionary, known as the compatibility dictionary, that allows an application to refer to dictionary definitions without concern about which type of dictionary format the definitions are stored in.

The compatibility dictionary is a CDO-format dictionary whose directory hierarchy matches that of the DMU-format dictionary (if any) on the system.

NOTE

> The compatibility dictionary is an installation option for CDD/Plus. Even if you do not have a compatibility dictionary, an application program can refer to both types of dictionary. In this case, the user must be careful to refer to CDO-format dictionaries with an anchor origin path name, and to the DMU-format dictionary with a CDD$TOP path name. Anchor origin path names are described in the next section.

Refer to CDD/Plus documentation for detailed information on the CDO utility and the compatibility dictionary.

23.2.2 Dictionary Path Names

To access dictionary definitions, you must specify a path name in the %INCLUDE %FROM %CDD or %REPORT %DEPENDENCY directive. The path name tells CDD/Plus where to locate a particular data definition in its directory. A CDD/Plus path name consists of a string of names separated by periods and enclosed in quotation marks.

The origin is the top, or root, of a dictionary directory. This directory contains other dictionary directories, subdictionary directories, and objects. For example:

```
%INCLUDE %FROM %CDD "CDD$TOP.BASIC.EMPLOYEE_DATA"
```

In this example, the path name CDD$TOP.BASIC.EMPLOYEE_DATA points to the root dictionary directory, CDD$TOP. The root directory CDD$TOP contains the dictionary directory BASIC, which in turn contains the object EMPLOYEE_DATA, a data definition.

VAX BASIC allows three types of valid path name parameters when referring to CDO dictionary definitions. They differ in the method of specifying the dictionary origin.

- Dictionary anchor path name

  An anchor path name begins with an anchor, which is a VMS directory specification, as the dictionary origin. The anchor specifies the VMS directory that contains the CDO dictionary. This is known as the CDO naming convention. In the following example, MYNODE::DISK$2:[MYDIRECTORY] is the anchor:

  ```
  MYNODE::DISK$2:[MYDIRECTORY]PERSONNEL.EMPLOYEES_REC
  ```

- CDD$TOP path name

  You use this to refer to either DMU-format dictionary definitions or CDO-format dictionary definitions in a compatibility dictionary. The path origin is always CDD$TOP. This is known as the DMU naming convention. For example:

  ```
  CDD$TOP.PERSONNEL.EMPLOYEES_REC
  ```

- Relative path name

  CDD/Plus always begins its search at CDD$TOP (or at the anchor you specify) unless you define another directory or object to be the start of your directory. You can do this by assigning the name of a dictionary directory to the logical name CDD$DEFAULT. For example:

  ```
  $  DEFINE CDD$DEFAULT CDD$TOP.BASIC
  ```

  Using this command defines the dictionary directory CDD$TOP.BASIC as the default start of your directory. You can override the defined default by specifying CDD$TOP in a path name.

  You can omit the origin of a path name and specify a relative path name. Any path name that does not begin with either CDD$TOP or an anchor is automatically appended to the current CDD$DEFAULT. For example, you can specify:

  ```
  PERSONNEL.EMPLOYEES_REC
  ```

  If CDD$DEFAULT is MYNODE::MY$DISK:[MYDIR], the relative path name is the same as:

  ```
  MYNODE::MY$DISK:[MYDIR]PERSONNEL.EMPLOYEES_REC.
  ```

  Similarly, if CDD$DEFAULT is CDD$TOP.MYDIR, the relative path name is the same as:

  ```
  CDD$TOP.MYDIR.PERSONNEL.EMPLOYEES_REC.
  ```

23.2.3 Dictionary Entities

Several types of entities can exist in a dictionary. DMU-format and CDO-format dictionaries each contain record entities, database entities, and form entities, for example.

When you compile a program with CDD/Plus support enabled, the compiler creates a construct known as a compiled module entity in the CDO-format dictionary. Only CDO-format dictionaries can contain compiled module entities.

A compiled module entity is created for the main program and each SUB, PICTURE subprogram, and FUNCTION. Each compiled module entity points to a file entity that contains the fully qualified VMS file specification of the .OBJ file. Several compiled module entities can point to the same file entity. Compiled module entities are put in the current CDD$DEFAULT directory.

The VAX BASIC compiler creates a compiled module entity (and relationships in CDD/Plus dictionaries that depend on compiled module entities) only if the compilation generates an object file. Therefore, compiled module entities are not generated if you specify the /NOOBJECT qualifier on the command line or if the program has compilation errors.

23.2.4 Dictionary Relationships

Relationships occur in a CDO-format dictionary when two or more CDO entity definitions are connected in any of several possible ways. For example, you can relate a set of field definitions to a record definition by including the field names in the record definition. Consider the following sequence of CDO commands:

```
CDO> DEFINE FIELD REG_DOG_NAME DATATYPE IS TEXT SIZE IS 25 CHARACTERS.
CDO> DEFINE FIELD BREED DATATYPE IS TEXT SIZE IS 20 CHARACTERS.
CDO> DEFINE FIELD CALL_NAME DATATYPE IS TEXT SIZE IS 20 CHARACTERS.
CDO> DEFINE FIELD OWNER_NUMBER DATATYPE IS TEXT SIZE IS 5.
     .
     .
     .
CDO> DEFINE RECORD DOG_REC.
cont>REG_DOG_NAME.
cont>BREED.
cont>CALL_NAME.
cont>OWNER_NUMBER.
cont>END RECORD.
```

This sequence defines four field entities initially, and then defines a record entity containing those four fields. Thus, CDD/Plus creates a relationship between the record DOG_REC and each field that DOG_REC uses.

You can create other types of relationships from a VAX BASIC program by using %INCLUDE and %REPORT directives in conjunction with the compilation qualifier /DEPENDENCY_DATA. Later sections will show you how to do that.

See CDD/Plus documentation for detailed information about relationships in a CDO-format dictionary.

23.2.5 Extracting CDD/Plus Data Definitions in VAX BASIC

A data definition is one type of a CDD/Plus object. In VAX BASIC, you can extract only data definition objects into your program.

To extract a CDD/Plus data definition in VAX BASIC, specify the %INCLUDE %FROM %CDD compiler directive and a CDD/Plus path name. You can use this to extract a data definition from either a DMU-format or CDO-format dictionary. For example:

```
%INCLUDE %FROM %CDD "CDD$TOP.BASIC.BASICDEF"
```

The %INCLUDE %FROM %CDD directive extracts the CDD/Plus data definition you specify, and translates it into VAX BASIC syntax. In VAX BASIC, the syntax for data definitions or data structures is defined by the RECORD statement.

After a CDD/Plus data definition is translated into RECORD statement syntax, you can reference the name of the RECORD statement in your VAX BASIC programs. After compilation, the translated RECORD statement is included as a part of your program's listing.

The following is an example of a CDD/Plus data definition and the translated VAX BASIC RECORD statement. In general, the examples in this chapter are of DMU-format CDD/Plus data definitions that were written in the VAX Common Data Definition Language (CDDL). In all examples, a CDDL data definition is displayed in lowercase letters and the translated RECORD statement is displayed in uppercase letters.

CDDL Definition

```
define record
CDD$top.basic.basicdef
        description is

           /* This is an example record containing
           only data types supported by VAX BASIC */.
        employee structure.
                street          datatype is text
                                size is 30 characters.
                city            datatype is text
                                size is 30 characters.
                state           datatype is text
                                size is 2 characters.
                zip_code structure.
                    new         datatype is packed decimal
                                size is 4 digits.
                    old         datatype is packed decimal
                                size is 5 digits.
                end zip_code structure.
                emp_number      datatype is signed word.
                wage_class      datatype is text
                                size is 2 characters.
                salary_ytd      datatype is d_floating.
        end employee structure.
end basicdef.
```

Translated RECORD Statement

```
    1         %INCLUDE %FROM %CDD "CDD$TOP.BASIC.BASICDEF"
       C1             !   This is an example record containing
       C1             !   only data types supported by VAX BASIC
       C1             RECORD  EMPLOYEE                        ! UNSPECIFIED
       C1               STRING  STREET   = 30                 ! TEXT
       C1               STRING  CITY   = 30                   ! TEXT
       C1               STRING  STATE   = 2                   ! TEXT
       C1               GROUP   ZIP_CODE                      ! UNSPECIFIED
       C1                 DECIMAL(4 ,0 ) NEW                  ! PACKED DECIMAL
       C1                 DECIMAL(5 ,0 ) OLD                  ! PACKED DECIMAL
       C1               END GROUP
       C1               WORD    EMP_NUMBER                    ! SIGNED WORD
       C1               STRING  WAGE_CLASS   = 2              ! TEXT
       C1               DOUBLE  SALARY_YTD                    ! D_FLOATING
       C1             END RECORD
```

When VAX BASIC translates a CDD/Plus data definition, it does the following:

- For DMU-format definitions, it takes the field name specified in the first CDDL STRUCTURE statement and assigns that name to the VAX BASIC RECORD. For CDO-format definitions, it takes the record name from the CDO DEFINE RECORD statement and assigns that name to the VAX BASIC record. In the preceding example, for instance, the first CDD/Plus structure statement is *employee structure*. When VAX BASIC translates this line of a CDD/Plus data definition, it names the

RECORD *EMPLOYEE*. If this first structure is unnamed, VAX BASIC signals the error "Record from CDD/Plus does not have a record name".

- Translates the field name in any subsequent CDD/Plus STRUCTURE statement to be the name of a group. For instance, in the preceding example, the second STRUCTURE statement, *zip_code structure*, is translated to *GROUP ZIP_CODE*.
- Translates subordinate field names in CDD/Plus STRUCTURE statements to elementary components in the RECORD statement. In the preceding example, for instance, the subordinate field name *street* is translated to *STRING STREET*.

If you specify the /LIST qualifier, when VAX BASIC translates a CDD/Plus data definition, it does the following:

- Begins each line of the RECORD statement with the letter "C" followed by a number. The "C" tells you that the RECORD statement was translated from a CDD/Plus data definition. The number tells you the nesting level of the %INCLUDE %FROM %CDD directive within the source program. For example, if your source program directly extracts a CDD/Plus record definition, then each line is preceded by a "C1". If CDD/Plus extraction came from a file included in the source program, then each line of the record definition is preceded by a "C2", and so on.
- Includes the explanatory text in CDDL DESCRIPTION clause as comment fields.
- Translates the data type text in the subordinate field to a comment field that tells you the data type of each elementary RECORD component. For example, the comment *! TEXT* tells you that *STRING STREET* is a text data type.

VAX BASIC requires that a CDD/Plus data definition include a minimum of one structure to be translated into a RECORD statement. If a CDD/Plus data definition contains only a single subordinate field (without a structure), VAX BASIC signals an error message because it cannot give a name to the RECORD statement. For this reason, you cannot include a CDO FIELD definition in a VAX BASIC program. You can, however, include CDO RECORD definitions that contain that field.

For more information on how VAX BASIC translates CDD/Plus data types, see Section 23.9.

23.3 Using CDD/Plus with VAX BASIC

When dependency recording is in effect, the compiler updates the CDO-format dictionary to show what dictionary data entities are used by the program (in other words, the data dependencies created by the compilation).

To take advantage of dependency recording, the VAX BASIC user must do the following:

- Use either or both of two VAX BASIC lexical directives in the source program, %INCLUDE %FROM %CDD and %REPORT %DEPENDENCY, to define the dependency relationships you want to create between your program and definitions in the CDO-format dictionary. These directives will be described further in later sections.
- Establish a CDO-format dictionary as CDD$DEFAULT.
- Include the /DEPENDENCY_DATA qualifier in the BASIC command that compiles the module.

23.3.1 The /DEPENDENCY_DATA Qualifier

When you compile a program that references CDO-format data definitions, you can include the /DEPENDENCY_DATA qualifier in the BASIC command line. That qualifier tells the compiler to create dependency relationships (as defined in the program by %INCLUDE and %REPORT directives) and update the dictionary to show those relationships.

To prevent update of the dictionary, specify /NODEPENDENCY_DATA (the default). In this case, the compiler can extract record definitions from the dictionary (as specified by %INCLUDE %FROM %CDD directives in the program), but will not update the dictionary. In other words, the compilation will not add compiled module entities and file entities to the dictionary, nor create dependency relationships in the dictionary, unless you specify the /DEPENDENCY_DATA qualifier.

23.3.2 Creating Relationships with Included Record Definitions

In Section 23.2.4, an example defined a record description as a set of fields (thus establishing a simple relationship in CDD/Plus between the record and its fields). With that record description defined, you can include it in a VAX BASIC program.

With either a DMU-format or CDO-format dictionary, the compiler can extract a record description into a program. To accomplish this, you must use the %INCLUDE lexical directive in the source program. The format is as follows:

```
%INCLUDE %FROM %CDD "pathname"
```

For example, the following BASIC source code extracts a record description named *ADDRESS_REC* from CDD/Plus:

```
PROGRAM EXAMPLE1
%INCLUDE %FROM %CDD "CDD$TOP.SMITH.ADDRESS_REC"
DECLARE ADDRESS_REC TEST_RECORD
INPUT "First name";TEST_RECORD::FIRST_NAME
INPUT "Last name";TEST_RECORD::LAST_NAME
INPUT "Address";TEST_RECORD::ADDRESS
INPUT "City";TEST_RECORD::CITY
INPUT "State";TEST_RECORD::STATE
INPUT "Zip code";TEST_RECORD::ZIP_CODE

PRINT TEST_RECORD::FIRST_NAME; TEST_RECORD::LAST_NAME
PRINT TEST_RECORD::ADDRESS
PRINT TEST_RECORD::CITY; TEST_RECORD::STATE; TEST_RECORD::ZIP_CODE
```

The listing shows the physical content of the record, as in the following listing excerpt:

```
  1            PROGRAM EXAMPLE1
  2            %INCLUDE %FROM %CDD "CDD$TOP.SMITH.ADDRESS_REC"
     C1             RECORD  ADDRESS_REC                    ! UNSPECIFIED
     C1               STRING  FIRST_NAME  = 20             ! TEXT
     C1               STRING  LAST_NAME  = 30              ! TEXT
     C1               STRING  ADDRESS  = 40                ! TEXT
     C1               STRING  CITY  = 20                   ! TEXT
     C1               STRING  STATE  = 2                   ! TEXT
     C1               DECIMAL(5 ,0 ) ZIP_CODE              ! PACKED DECIMAL
     C1             END RECORD
  3            DECLARE ADDRESS_REC TEST_RECORD
  4            INPUT "First name";TEST_RECORD::FIRST_NAME
  5            INPUT "Last name";TEST_RECORD::LAST_NAME
  6            INPUT "Address";TEST_RECORD::ADDRESS
  7            INPUT "City";TEST_RECORD::CITY
  8            INPUT "State";TEST_RECORD::STATE
  9            INPUT "Zip code";TEST_RECORD::ZIP_CODE
 10
 11            PRINT TEST_RECORD::FIRST_NAME; TEST_RECORD::LAST_NAME
 12            PRINT TEST_RECORD::ADDRESS
 13            PRINT TEST_RECORD::CITY; TEST_RECORD::STATE; TEST_RECORD::ZIP_CODE
```

In the case of a CDO-format dictionary, you can also cause the dictionary to create and maintain a formal relationship between the record description and the compiled module entity that represents your program in the dictionary.

This is known as a CDD$COMPILED_DEPENDS_ON relationship. To accomplish this relationship, you must specify the /DEPENDENCY_DATA qualifier when you compile the program.

```
$ BASIC/DEPENDENCY_DATA EX1.BAS
```

If you specify the /DEPENDENCY_DATA qualifier to the VAX BASIC compiler, the compiled module entity is created and updated to reflect the fact that your program uses that record. If someone wants to change the data definition at a later date, CDO allows that person to find out what programs depend on it before doing so. For example:

```
CDO> DIRECTORY
 Directory SYS$COMMON:[CDDPLUS]SMITH
ADDRESS;1                                          FIELD
ADDRESS_REC;1                                      RECORD
CITY;1                                             FIELD
EXAMPLE1;1                                         CDD$COMPILED_MODULE
FIRST_NAME;1                                       FIELD
LAST_NAME;1                                        FIELD
STATE;1                                            FIELD
ZIP_CODE;1                                         FIELD
    .
    .
    .
```

You can use the CDO SHOW USES command to find out what programs use a dictionary definition. For example:

```
CDO> SHOW USES ADDRESS_REC
Owners of SYS$COMMON:[CDDPLUS]SMITH.ADDRESS_REC;1
|   SYS$COMMON:[CDDPLUS]SMITH.EXAMPLE1;1  (Type : CDD$COMPILED_MODULE)
|   |   via CDD$COMPILED_DEPENDS_ON
```

You can also use CDO to find out what dictionary definitions a program uses. For example:

```
CDO> SHOW USED_BY EXAMPLE1
Members of SYS$COMMON:[CDDPLUS]SMITH.EXAMPLE1;1
|   EX1                             (Type : CDD$FILE)
|   |   via CDD$IN_FILE
|   SYS$COMMON:[CDDPLUS]SMITH.ADDRESS_REC;1  (Type : RECORD)
|   |   via CDD$COMPILED_DEPENDS_ON
```

23.4 Creating Relationships for Referenced Dictionary Entities

The compiler can create a relationship between a compiled module entity and any dictionary entity that a program references (such as an Rdb/VMS database or a form definition). The referenced dictionary entity is not

copied to the program. Instead, the compiled program simply references the dictionary entity at run time, or with the help of a preprocessor.

To create such relationships in a BASIC program, you must use a %REPORT %DEPENDENCY lexical directive in the source program and specify the /DEPENDENCY_DATA qualifier when you compile the program. The format is as follows:

```
%REPORT %DEPENDENCY "pathname" ["relationship-type"]
```

The “pathname” parameter identifies the dictionary item that the compiled object module references. The path name can specify a CDO-format dictionary item (with an anchor as the first element), or it can specify a CDO-format item in the compatibility dictionary (which can be specified either as a CDD$TOP path name or as an anchor path name). See Section 23.2.2 for a full description of the path name options.

The optional “relationship-type” parameter determines the type of relationship by specifying a CDD/Plus protocol. There are many valid values; refer to CDD/Plus documentation for full information. The most commonly-used type of relationship for VAX BASIC users is:

```
CDD$COMPILED_DEPENDS_ON
```

This specifies a relationship that links a compiled object module to the element that goes into the compilation. This is the default.

The %REPORT %DEPENDENCY directive is meaningful only when the following three conditions are true:

- The /DEPENDENCY_DATA qualifier is specified in the BASIC command line. (If it is not specified, the compiler checks syntax but does not update the dictionary to reflect this usage of the item.)
- Your current CDD$DEFAULT points to a directory in a CDO dictionary.
- The dictionary item specified by pathname is in a CDO-format dictionary. (No relationship can be created in a DMU-format dictionary.)

Suppose the VAX BASIC program DOG_REPORT.BAS contains the following directive:

```
%REPORT %DEPENDENCY "DISK1$:[CDDPLUS.BASIC]SMITH.DOG_DATABASE"
```

Use the /DEPENDENCY_DATA qualifier when you compile the program:

```
$ BASIC/DEPENDENCY_DATA DOG_REPORT
```

After the compilation, the dictionary contains the following:

```
CDO> DIR

 Directory DISK1$:[CDDPLUS.BASIC]SMITH

BREED;1                                          FIELD
CALL_NAME;1                                      FIELD
DOG_REPORT$MAIN;1                                CDD$COMPILED_MODULE
DOG_DATABASE;1                                   CDD$DATABASE
DOG_INFORMATION;1                                CDD$RMS_DATABASE
DOG_REC;1                                        RECORD
OWNER_NUMBER;1                                   FIELD
REG_DOG_NAME;1                                   FIELD

CDO> SHOW USES DOG_DATABASE

Owners of DISK1$:[CDDPLUS.BASIC]SMITH.DOG_DATABASE;1
|   DISK1$:[CDDPLUS.BASIC]SMITH.DOG_REPORT$MAIN;1  (Type : CDD$COMPILED_MODULE)
|   |   via CDD$COMPILED_DEPENDS_ON

CDO> SHOW USED_BY DOG_REPORT$MAIN
Members of DISK1$:[CDDPLUS.BASIC]SMITH.DOG_REPORT$MAIN;1
|   DOG_REPORT                          (Type : CDD$FILE)
|   |   via CDD$IN_FILE
|   DISK1$:[CDDPLUS.BASIC]SMITH.DOG_DATABASE;1  (Type : CDD$DATABASE)
|   |   via CDD$COMPILED_DEPENDS_ON
```

23.5 Specifying a CDD History List Entry

When your VAX BASIC program accesses CDD/Plus, you have the option of entering a history list entry in the CDD/Plus database. The history list entry provides a history of users that access CDD/Plus.

You enter a history list entry by specifying the DCL command qualifier /AUDIT. For example:

```
$ BASIC/DEPENDENCY_DATA/AUDIT="History text goes here" EX1.BAS
```

Note that instead of typing the text directly on the command line, you can also specify a file specification that contains the history entry.

When you specify /AUDIT, a history list entry is created for each compiled module entity that the compilation creates. In addition, the compilation will add a history list entry to each data definition that your program extracts with the %INCLUDE %FROM %CDD directive.

You can display history list information using the CDO utility. For example:

```
CDO> SHOW GENERIC CDD$COMPILED_MODULE EXAMPLE1 /AUDIT
Definition of EXAMPLE1   (Type : CDD$COMPILED_MODULE)
|   History entered by SMITH ([SMITH])
|       using VAX BASIC V3.4
|       to CREATE definition on 25-APR-1989 13:04:01.48
|       Explanation:
|               "History text goes here"
```

23.6 CDD/Plus Arrays

VAX CDD/Plus supports three types of arrays:

- Multidimensional arrays (the ARRAY clause)
- One-dimensional, fixed length arrays (the OCCURS clause or ARRAY clause)
- One-dimensional, variable length arrays (the OCCURS DEPENDING ON clause—note that VAX BASIC does not support this clause)

Arrays are valid for any CDD/Plus field. VAX BASIC does not support dimensions on a RECORD statement. You cannot, therefore, declare an entire RECORD statement as an array. However, you can dimension an instance of the record.

The following is an example of a CDDL data definition containing arrays and the corresponding VAX BASIC RECORD statement.

CDDL Definition

```
define record CDD$top.basic.array1
    description is

        /* test arrays */.

    array_1 structure.
        my_byte         array 0:2           datatype        signed byte.
        my_string       array 0:10          datatype        text size 10.
        my_s_real       array 0:2 0:4       datatype        f_floating.
        my_d_real       array 1:3           datatype        d_floating.
        my_g_real       occurs 4 times      datatype        g_floating.
        my_h_real       occurs 4 times      datatype        h_floating.
    end array_1 structure.
end array1.
```

Translated RECORD Statement

```
1           %INCLUDE %FROM %CDD "CDD$TOP.BASIC.ARRAY1"
   C1                !   test arrays
   C1                RECORD  ARRAY_1                            ! UNSPECIFIED
   C1                  BYTE    MY_BYTE(0 TO 2)                  ! SIGNED BYTE
   C1                  STRING  MY_STRING(0 TO 10) = 10          ! TEXT
   C1                  SINGLE  MY_S_REAL(0 TO 2,0 TO 4)         ! F_FLOATING
   C1                  DOUBLE  MY_D_REAL(1 TO 3)                ! D_FLOATING
   C1                  GFLOAT  MY_G_REAL(1 TO 4)                ! G_FLOATING
   C1                  HFLOAT  MY_H_REAL(1 TO 4)                ! H_FLOATING
   C1                END RECORD
```

By default, arrays in CDD/Plus are row-major. This means that when storage is allocated for the array, the rightmost subscript varies fastest. All VAX BASIC arrays are row-major. VAX BASIC does not support column-major arrays. If a CDD/Plus definition containing a column-major array is extracted, VAX BASIC signals the error "<array-name> from CDD/Plus is a column major array".

By default, VAX BASIC extracts an array field from CDD/Plus with the bounds specified in the data definition. However, if you use the qualifier /OLD_VERSION=CDD/Plus_ARRAYS when you extract a data definition, VAX BASIC translates the data definition with lower bounds as zero and adjusts the upper bounds. This means that an array with dimensions of (2,5) in CDD/Plus is translated by VAX BASIC to be an array with a lower bound of 0 and an upper bound of 3. VAX BASIC issues an informational message to confirm the array bounds when you use this qualifier.

The following CDD/Plus data definition and corresponding RECORD statement were extracted with the /OLD_VERSION=CDD_ARRAYS qualifier.

CDDL Definition

```
define record CDD$top.basic.array2
    description is

        /* test arrays with /old_version=CDD_arrays qualifier */.

    array_2 structure.
        my_byte         array 0:2           datatype        signed byte.
        my_string       array 0:10          datatype        text size 10.
        my_s_real       array 0:2 0:4       datatype        f_floating.
        my_d_real       array 1:3           datatype        d_floating.
        my_g_real       occurs 4 times      datatype        g_floating.
        dep_item                            datatype        signed longword.
        my_h_real       occurs 4 times
                                            datatype        h_floating.
    end array_2 structure.
end array2.
```

Translated RECORD Statement

```
1          %INCLUDE %FROM %CDD "CDD$TOP.BASIC.ARRAY2"
   C1              !   test arrays with /old_version=CDD_arrays qualifier
   C1              RECORD  ARRAY_2                           ! UNSPECIFIED
   C1                BYTE    MY_BYTE(0 TO 2)                 ! SIGNED BYTE
   C1                STRING  MY_STRING(0 TO 10) = 10         ! TEXT
   C1                SINGLE  MY_S_REAL(0 TO 2,0 TO 4)        ! F_FLOATING
   C1                DOUBLE  MY_D_REAL(0 TO 2)               ! D_FLOATING
   C1                GFLOAT  MY_G_REAL(0 TO 3)               ! G_FLOATING
   C1                LONG    DEP_ITEM                        ! SIGNED LONGWORD
   C1                HFLOAT  MY_H_REAL(0 TO 3)               ! H_FLOATING
   C1              END RECORD
```

23.7 CDD/Plus Variants

A variant comprises two or more fields of a record that provide alternative descriptions for the same portion of a record.

The following is an example of a CDDL data definition containing variant fields and the corresponding VAX BASIC RECORD statement.

CDDL Definition

```
define record CDD$top.basic.variant_example
    description is

        /* test simple variant */.
    variant_example structure.
        my_string datatype text size 9.
        variants.
            variant.
                my_s_real       datatype        f_floating.
                my_d_real       datatype        d_floating.
            end variant.
            variant.
                my_g_real       datatype        g_floating.
                my_h_real       datatype        h_floating.
            end variant.
        end variants.
                my_byte         datatype        signed byte.
   end variant_example structure.
end variant_example.
```

Translated RECORD Statement

```
1         %INCLUDE %FROM %CDD "CDD$TOP.BASIC.VARIANT_EXAMPLE"
   C1             !   test simple variant
   C1             RECORD  VARIANT_EXAMPLE                 ! UNSPECIFIED
   C1               STRING  MY_STRING  = 9                ! TEXT
   C1               VARIANT
   C1               CASE
   C1                 SINGLE  MY_S_REAL                   ! F_FLOATING
   C1                 DOUBLE  MY_D_REAL                   ! D_FLOATING
   C1               CASE
   C1                 GFLOAT  MY_G_REAL                   ! G_FLOATING
   C1                 HFLOAT  MY_H_REAL                   ! H_FLOATING
   C1               END VARIANT
   C1               BYTE    MY_BYTE                       ! SIGNED BYTE
   C1             END RECORD
```

VAX CDD/Plus data definitions sometimes contain VARIANTS OF field description statements as well as simple variants. A CDDL or CDO VARIANTS OF statement names a tag variable whose value at run time determines which of the variant fields is the current variant. VAX BASIC does not support the VARIANTS OF statement. If a CDD/Plus data definition containing a VARIANTS OF statement is extracted, VAX BASIC signals the informational message, "<number> tag value from CDD/Plus ignored" and treats the VARIANTS OF as an ordinary variant and ignores the tag value.

23.8 The NAME FOR BASIC Clause

VAX BASIC supports the CDDL and CDO field attribute clause NAME FOR BASIC.

The CDDL field attribute clause NAME FOR BASIC declares a facility-specific name for a field. For example:

```
name for basic is "subject_name$"
```

When you assign a name using the NAME FOR BASIC clause in a CDDL or CDO data definition, VAX BASIC recognizes only this name when you refer to the field. Note that when you use the NAME FOR BASIC clause, you can place dollar sign ($) and percent sign (%) suffixes in your RECORD statement field names.

The following example is a CDDL data definition containing the NAME FOR BASIC clause, and the corresponding VAX BASIC RECORD statement.

CDDL Definition

```
define record city_study
    description is

       /* This example formats data resulting from a
       study on the relationship between place of birth
       and earning potential */.
    info structure.
        subject_name                    datatype text size 10
                                        name for basic is "subject_name$".
        birth_city                      datatype text size 10
                                        name for basic is "city_of_birth$".
        salary                          datatype signed byte
                                        name for basic is "salary%".
    end info structure.
end city_study.
```

Translated RECORD Statement

```
1          %INCLUDE %FROM %CDD "CDD$TOP.BASIC.CITY_STUDY"
   C1              !   This example formats data resulting from a
   C1              !         study on the relationship between place of birth
   C1              !         and earning potential
   C1              RECORD  INFO                         ! UNSPECIFIED
   C1                STRING  SUBJECT_NAME$  = 10        ! TEXT
   C1                STRING  CITY_OF_BIRTH$  = 10       ! TEXT
   C1                BYTE    SALARY%                    ! SIGNED BYTE
   C1              END RECORD
```

Be careful when you use the NAME FOR BASIC clause because it enables you to assign completely different names to the same field.

For more information about the CDDL NAME FOR BASIC field attribute clause, see the CDD/Plus documentation.

23.9 CDD/Plus Data Types

VAX BASIC supports only a subset of CDD/Plus data types. They are described in Table 23–1.

Table 23–1: Supported CDD/Plus Data Types

CDD/Plus Data Type	VAX BASIC Translation
TEXT	STRING
SIGNED BYTE	BYTE

(continued on next page)

Table 23–1 (Cont.): Supported CDD/Plus Data Types

CDD/Plus Data Type	VAX BASIC Translation
SIGNED WORD	WORD
SIGNED LONGWORD	LONG
F_FLOATING	SINGLE
D_FLOATING	DOUBLE
G_FLOATING	GFLOAT
H_FLOATING	HFLOAT
PACKED DECIMAL	DECIMAL

If a CDD/Plus data definition containing an unsupported data type is extracted, VAX BASIC signals the informational message "Datatype in CDD/Plus not supported, substituted group for: <field-name>" and translates the data type by creating a group to contain the data type field. The group name is the name of the unsupported data type followed by the text "_VALUE". This allows you to access the field name within the group.

An example of how VAX BASIC translates unsupported CDD/Plus data types is shown in the following CDDL data definition and corresponding VAX BASIC RECORD statement.

CDDL Definition

```
define record CDD$top.basic.stock
        description is
           /* this is an example data definition that contains
           data types not supported by VAX BASIC */.

        stock structure.
                product_no      datatype is text
                                size is 8 characters.
                date_ordered    datatype is date.
                status_code     datatype is unsigned byte.
                quantity        datatype is unsigned longword
                                aligned on longword.
                location        array 1:4
                                datatype is text
                                size is 30 characters.
                unit_price      datatype is longword.
       end stock structure.
end stock.
```

Translated RECORD Statement

```
1           %INCLUDE %FROM %CDD "CDD$TOP.BASIC.STOCK"
   C1               !  This is an example data definition that contains
   C1               !                  data types not supported by VAX BASIC
   C1               RECORD  STOCK                      ! UNSPECIFIED
   C1                 STRING  PRODUCT_NO  = 8          ! TEXT
   C1                 GROUP   DATE_ORDERED             ! DATE
   C1                   STRING  STRING_VALUE  = 8
   C1                 END GROUP
   C1                 GROUP   STATUS_CODE              ! UNSIGNED BYTE
   C1                   BYTE    BYTE_VALUE
   C1                 END GROUP
   C1                 STRING  FILL = 3
   C1                 GROUP   QUANTITY                 ! UNSIGNED LONGWORD
   C1                   LONG    LONG_VALUE
   C1                 END GROUP
   C1                 STRING  LOCATION(1 TO 4) = 30    ! TEXT
   C1                 GROUP   UNIT_PRICE               ! UNSIGNED LONGWORD
   C1                   LONG    LONG_VALUE
   C1                 END GROUP
   C1               END RECORD
%BASIC-I-CDD/PlusSUBGRO,          data type in CDD/Plus not supported,
                substituted group for: STOCK::DATE_ORDERED.
%BASIC-I-CDD/PlusSUBGRO,          data type in CDD/Plus not supported,
                substituted group for: STOCK::STATUS_CODE.
%BASIC-I-CDD/PlusSUBGRO,          data type in CDD/Plus not supported,
                substituted group for: STOCK::QUANTITY.
%BASIC-I-CDD/PlusSUBGRO,          data type in CDD/Plus not supported,
                substituted group for: STOCK::UNIT_PRICE.
```

Table 23–2 describes CDD/Plus data types not supported by VAX BASIC and their translation.

Table 23–2: Unsupported CDD/Plus Data Types

CDD/Plus Data Type	VAX BASIC Translation
UNSIGNED BYTE	GROUP CDD/Plus-field-name BYTE BYTE_VALUE END GROUP
UNSIGNED WORD	GROUP CDD/Plus-field-name WORD WORD_VALUE END GROUP
UNSIGNED LONGWORD	GROUP CDD/Plus-field-name LONG LONG_VALUE END GROUP

(continued on next page)

Table 23–2 (Cont.): Unsupported CDD/Plus Data Types

CDD/Plus Data Type	VAX BASIC Translation
SIGNED QUADWORD	GROUP CDD/Plus-field-name STRING STRING_VALUE = 8 END GROUP
UNSIGNED QUADWORD	GROUP CDD/Plus-field-name STRING STRING_VALUE = 8 END GROUP
SIGNED OCTAWORD	GROUP CDD/Plus-field-name STRING STRING_VALUE = 16 END GROUP
UNSIGNED OCTAWORD	GROUP CDD/Plus-field-name STRING STRING_VALUE = 16 END GROUP
F_FLOATING COMPLEX	GROUP CDD/Plus-field-name SINGLE SINGLE_R_VALUE SINGLE SINGLE_I_VALUE END GROUP
D_FLOATING COMPLEX	GROUP CDD/Plus-field-name DOUBLE DOUBLE_R_VALUE DOUBLE DOUBLE_I_VALUE END GROUP
G_FLOATING COMPLEX	GROUP CDD/Plus-field-name GFLOAT GFLOAT_R_VALUE GFLOAT GFLOAT_I_VALUE END GROUP
H_FLOATING COMPLEX	GROUP CDD/Plus-field-name HFLOAT HFLOAT_R_VALUE HFLOAT HFLOAT_I_VALUE END GROUP
ZONED NUMERIC	GROUP CDD/Plus-field-name STRING STRING_VALUE = length END GROUP
UNSIGNED NUMERIC	GROUP CDD/Plus-field-name STRING STRING_VALUE = length END GROUP

(continued on next page)

Table 23–2 (Cont.): Unsupported CDD/Plus Data Types

CDD/Plus Data Type	VAX BASIC Translation
LEFT SEPARATE NUMERIC	GROUP CDD/Plus-field-name STRING STRING_VALUE = length + 1 END GROUP
LEFT OVERPUNCHED NUMERIC	GROUP CDD/Plus-field-name STRING STRING_VALUE = length END GROUP
RIGHT SEPARATE NUMERIC	GROUP CDD/Plus-field-name STRING STRING_VALUE = length + 1 END GROUP
RIGHT OVERPUNCHED NUMERIC	GROUP CDD/Plus-field-name STRING STRING_VALUE = length END GROUP
VARYING STRING	GROUP CDD/Plus-field-name WORD WORD_VALUE STRING STRING_VALUE = length END GROUP
BIT[1]	GROUP CDD/Plus-field-name STRING STRING_VALUE = length /8 END GROUP
DATE	GROUP CDD/Plus-field-name STRING STRING_VALUE = 8 END GROUP
POINTER	GROUP CDD/Plus-field-name LONG LONG_VALUE END GROUP

[1]CDD/Plus specifies bit field length in bits; VAX BASIC specifies string length in bytes. If the length in bits does not divide evenly into bytes, VAX BASIC signals the error "Field <fieldname> from CDD/Plus has bit offset or length".

(continued on next page)

Table 23–2 (Cont.): Unsupported CDD/Plus Data Types

CDD/Plus Data Type	VAX BASIC Translation
UNSPECIFIED	GROUP CDD/Plus-field-name STRING STRING_VALUE = length END GROUP
VIRTUAL FIELD	Ignored

The following sections describe how VAX BASIC translates CDD/Plus data types in greater detail.

23.9.1 Character String Data Types

There are two CDD/Plus character string data types, TEXT and VARYING STRING. The TEXT data type translates directly into the VAX BASIC STRING data type. VARYING STRING is not a supported VAX BASIC data type; therefore, VAX BASIC creates a group to contain the field.

The following example is a CDD/Plus definition that contains both the TEXT and VARYING STRING data types and the translated VAX BASIC RECORD statement.

CDDL

```
define record CDD$top.basic.strings
    description is

        /* test */.

    basicstrings structure.
        abc         datatype is text size is 10.
        xyz         datatype is varying string size is 16.
    end basicstrings structure.
end strings.
```

Translated RECORD Statement

```
1          %INCLUDE %FROM %CDD "CDD$TOP.BASIC.STRINGS"
   C1              !   test
   C1              RECORD  BASICSTRINGS                    ! UNSPECIFIED
   C1                STRING  ABC  = 10                     ! TEXT
   C1                GROUP   XYZ                           ! VARYING STRING
   C1                  WORD     WORD_VALUE
   C1                  STRING   STRING_VALUE   = 16
   C1                END GROUP
   C1              END RECORD
................1
%BASIC-I-CDD/PlusSUBGRO, 1:        data type in CDD/Plus not supported,
                substituted group for: BASICSTRINGS::XYZ.
```

In the VARYING STRING data type, the actual character string is preceded by a 16-bit count field. Therefore, VAX BASIC creates a WORD variable to hold the specified string length.

NOTE

The count field preceding the VARYING STRING is actually an UNSIGNED WORD. Therefore, the count field of a VARYING STRING whose length is greater than 32767 is interpreted by VAX BASIC as a negative number.

In the preceding example, the group name (XYZ) is the same name as a CDD/Plus field. Therefore, VAX BASIC supplies an additional name for the RECORD components. The supplied names are WORD_VALUE and STRING_VALUE. For example, the following program statement creates an instance of the record *BASICSTRINGS*, called *MY_REC*:

```
100      MAP (TEST) BASICSTRINGS MY_REC
```

The names you use to reference these components in VAX BASIC are MY_REC::XYZ::WORD_VALUE and MY_REC::XYZ::STRING_VALUE.

23.9.2 Integer Data Types

VAX CDD/Plus refers to integer data types as fixed-point data types. VAX CDD/Plus supports BYTE, WORD, LONGWORD, QUADWORD, and OCTAWORD integer data types. Each of these data types can have the following additional attributes:

- SIGNED
- UNSIGNED
- SIZE
- DIGITS

- FRACTION
- BASE
- SCALE

In CDDL, if integer data types are not specified as being signed or unsigned, the default is unsigned. VAX BASIC supports only signed BYTE, signed WORD, and signed LONGWORD integers. If a CDD/Plus data definition containing an unsigned BYTE, WORD, or LONGWORD integer is extracted, VAX BASIC signals the informational message "Datatype in CDD/Plus not supported, substituted group for: <field-name>", and creates a group to contain the field. Because the group name is the same as the CDD/Plus field name, VAX BASIC assigns a new name to the field. This is shown in the following CDDL data definition and corresponding VAX BASIC RECORD statement.

CDDL Definition

```
define record CDD$top.basic.integers
    description is

       /*Test of selected integer data types*/.
    basicint structure.
        my_byte         datatype is signed byte.
        my_ubyte        datatype is byte.
        my_word         datatype is signed word.
        my_uword        datatype is unsigned word.
        my_long         datatype is signed longword.
        my_ulong        datatype is unsigned longword.
    end basicint structure.
end integers.
```

Translated RECORD Statement

```
     1          %INCLUDE %FROM %CDD "CDD$TOP.BASIC.INTEGERS"
        C1              !  Test of selected integer data types
        C1              RECORD  BASICINT                        ! UNSPECIFIED
        C1                BYTE    MY_BYTE                       ! SIGNED BYTE
        C1                GROUP   MY_UBYTE                      ! UNSIGNED BYTE
        C1                  BYTE    BYTE_VALUE
        C1                END GROUP
        C1                WORD    MY_WORD                       ! SIGNED WORD
        C1                GROUP   MY_UWORD                      ! UNSIGNED WORD
        C1                  WORD    WORD_VALUE
        C1                END GROUP
        C1                LONG    MY_LONG                       ! SIGNED LONGWORD
        C1                GROUP   MY_ULONG                      ! UNSIGNED LONGWORD
        C1                  LONG    LONG_VALUE
        C1                END GROUP
        C1              END RECORD
...............1
```

```
%BASIC-I-CDDSUBGRO, 1:        data type in CDD/Plus not supported,
               substituted group for: BASICINT::MY_UBYTE.
%BASIC-I-CDDSUBGRO, 1:        data type in CDD/Plus not supported,
               substituted group for: BASICINT::MY_UWORD.
%BASIC-I-CDDSUBGRO, 1:        data type in CDD/Plus not supported,
               substituted group for: BASICINT::MY_ULONG.
```

When the preceding data definition is extracted from CDD/Plus, VAX BASIC signals an informational message for each of the unsigned data types, and names the CDD/Plus unsigned byte field BYTE_VALUE, CDD/Plus unsigned word field WORD_VALUE, and CDD/Plus unsigned longword field LONG_VALUE.

VAX BASIC does not support QUADWORD or OCTAWORD integers. If a CDD/Plus definition contains a QUADWORD or OCTAWORD integer, VAX BASIC signals the informational message "Datatype in CDD/Plus not supported, substituted group for: <field-name>" and creates a group to contain the field and a string component within the group. The string component is 8 bytes for QUADWORD integers and 16 bytes for OCTAWORD integers. See the following example.

CDDL Definition

```
define record CDD$top.basic.bigintegers
    description is

        /*Test of quadword and octaword integer data types*/.

    basicint structure.
        my_quad         datatype is signed quadword.
        my_octa         datatype is signed octaword.
    end basicint structure.
end bigintegers.
```

Translated RECORD Statement

```
     1          %INCLUDE %FROM %CDD "CDD$TOP.BASIC.BIGINTEGERS"
        C1              !  Test of quadword and octaword integer data types
        C1              RECORD  BASICINT                        ! UNSPECIFIED
        C1                GROUP   MY_QUAD                       ! SIGNED QUADWORD
        C1                  STRING  STRING_VALUE  = 8
        C1                END GROUP
        C1                GROUP   MY_OCTA                       ! SIGNED OCTAWORD
        C1                  STRING  STRING_VALUE  = 16
        C1                END GROUP
        C1              END RECORD
%BASIC-I-CDDSUBGRO,           data type in CDD/Plus not supported,
               substituted group for: BASICINT::MY_QUAD.
%BASIC-I-CDDSUBGRO,           data type in CDD/Plus not supported,
               substituted group for: BASICINT::MY_OCTA.
```

VAX CDD/Plus supports the SCALE keyword to specify an implied exponent in integer data types, and the BASE keyword (supported in CDDL only) to specify that the scale for a fixed-point field is to be interpreted in a numeric base other than 10. VAX BASIC does not support these integer attributes. Therefore, VAX BASIC signals the informational message "CDD/Plus specifies SCALE for <name>. Not supported", for fixed-point fields containing a SCALE specification and the error message, "CDD/Plus attributes for <name> are other than base 10", for fixed-point fields specifying a base other than 10. See the following example.

CDDL Definition

```
define record CDD$top.basic.funnyintegers
    description is

        /* Test of quadword and octaword integer data types */.

    basicint structure.
        my_byte         datatype is signed byte scale 2.
        my_long         datatype is signed longword base 8.
    end basicint structure.
end funnyintegers.
```

Translated RECORD Statement

```
     1           %INCLUDE %FROM %CDD "CDD$TOP.BASIC.FUNNYINTEGERS"
        C1              !   Test of quadword and octaword integer data types
        C1              RECORD  BASICINT                    ! UNSPECIFIED
        C1                GROUP  MY_BYTE                    ! SIGNED BYTE
        C1                  BYTE    BYTE_VALUE
        C1                END GROUP
        C1                LONG    MY_LONG                   ! SIGNED LONGWORD
        C1              END RECORD
%BASIC-I-CDDATTSCA,     CDD/Plus specifies SCALE for BASICINT::MY_BYTE. Not supported
%BASIC-E-CDDATTBAS,     CDD/Plus attributes for BASICINT::MY_LONG are other than base 10
```

At compilation time, VAX BASIC also signals these warning errors for each reference to fields that are not base 10 or that have a SCALE.

23.9.3 Floating-Point Data Types

VAX CDD/Plus supports F_floating, D_floating, G_floating, and H_floating data types. These correspond to the BASIC SINGLE, DOUBLE, GFLOAT, and HFLOAT data types, respectively. As with fixed-point data types, CDD/Plus also allows the specification of scale and base for floating-point data types. If a CDD/Plus data definition contains a floating-point field that specifies a SCALE or BASE, VAX BASIC signals the informational message "CDD/Plus specifies SCALE for <name>. Not supported" or the error message "CDD/Plus attributes for <name> are other than base 10". See the following example.

CDDL Definition

```
define record floats
    description is

       /*Test of floating-point data types*/.

    basicfloat structure.
        my_single       datatype is f_floating scale 3.
        my_double       datatype is d_floating base 16.
        my_gfloat       datatype is g_floating.
        my_hfloat       datatype is h_floating.
    end basicfloat structure.
end floats.
```

Translated RECORD Statement

```
     1          %INCLUDE %FROM %CDD "CDD$TOP.BASIC.FLOATS"
        C1              !  Test of floating-point data types
        C1              RECORD  BASICFLOAT                     ! UNSPECIFIED
        C1                GROUP   MY_SINGLE                    ! F_FLOATING
        C1                  SINGLE  SINGLE_VALUE
        C1                END GROUP
        C1                DOUBLE  MY_DOUBLE                    ! D_FLOATING
        C1                GFLOAT  MY_GFLOAT                    ! G_FLOATING
        C1                HFLOAT  MY_HFLOAT                    ! H_FLOATING
        C1              END RECORD
................1
%BASIC-I-CDDATTSCA, 1:   CDD/Plus specifies SCALE for BASICFLOAT::MY_SINGLE.
                         Not supported
%BASIC-E-CDDATTBAS, 1:   CDD/Plus attributes for BASICFLOAT::MY_DOUBLE
                         are other than base 10
```

In addition, CDD/Plus supports complex floating-point numbers, whereas VAX BASIC does not support them. Complex floating-point numbers consist of a real and an imaginary part. Each part requires the same amount of storage as a simple floating-point number. Therefore, each complex floating-point number requires twice as much storage as a simple floating-point number.

If a CDD/Plus data definition containing complex numbers is extracted, VAX BASIC signals the informational message, "Datatype in CDD/Plus not supported, substituted group for <field-name>", and creates a group to contain the field. As before, VAX BASIC uses the data type and *_VALUE* to create the group name, but because each complex number contains both a real and an imaginary part, VAX BASIC adds an "_R" to the name of the real part and an "_I" to the name of the imaginary part. This is illustrated in the following CDD/Plus data definition and corresponding VAX BASIC RECORD statement.

CDDL Definition

```
define record CDD$top.basic.complex
    description is

        /* test complex data types */.

        complex structure.
        my_s_complex_1  datatype        f_floating_complex.
        my_d_complex_1  datatype        d_floating_complex.
        my_g_complex_1  datatype        g_floating_complex.
        my_h_complex_1  datatype        h_floating_complex.
    end complex structure.
end complex.
```

Translated RECORD Statement

```
     1          %INCLUDE %FROM %CDD "CDD$TOP.BASIC.COMPLEX"
        C1              !   test complex data types
        C1              RECORD  COMPLEX                 ! UNSPECIFIED
        C1                GROUP   MY_S_COMPLEX_1        ! F_FLOATING_COMPLEX
        C1                  SINGLE  SINGLE_R_VALUE
        C1                  SINGLE  SINGLE_I_VALUE
        C1                END GROUP
        C1                GROUP   MY_D_COMPLEX_1        ! D_FLOATING_COMPLEX
        C1                  DOUBLE  DOUBLE_R_VALUE
        C1                  DOUBLE  DOUBLE_I_VALUE
        C1                END GROUP
        C1                GROUP   MY_G_COMPLEX_1        ! G_FLOATING_COMPLEX
        C1                  GFLOAT  GFLOAT_R_VALUE
        C1                  GFLOAT  GFLOAT_I_VALUE
        C1                END GROUP
        C1                GROUP   MY_H_COMPLEX_1        ! H_FLOATING_COMPLEX
        C1                  HFLOAT  HFLOAT_R_VALUE
        C1                  HFLOAT  HFLOAT_I_VALUE
        C1                END GROUP
        C1              END RECORD
................1
%BASIC-I-CDDSUBGRO, 1:          data type in CDD/Plus not supported,
                substituted group for: COMPLEX::MY_S_COMPLEX_1.
%BASIC-I-CDDSUBGRO, 1:          data type in CDD/Plus not supported,
                substituted group for: COMPLEX::MY_D_COMPLEX_1.
%BASIC-I-CDDSUBGRO, 1:          data type in CDD/Plus not supported,
                substituted group for: COMPLEX::MY_G_COMPLEX_1.
%BASIC-I-CDDSUBGRO, 1:          data type in CDD/Plus not supported,
                substituted group for: COMPLEX::MY_H_COMPLEX_1.
```

23.9.4 Decimal String Data Types

VAX CDD/Plus supports the following forms of decimal string data types:

- LEFT OVERPUNCHED NUMERIC
- LEFT SEPARATE NUMERIC
- RIGHT OVERPUNCHED NUMERIC

- RIGHT SEPARATE NUMERIC
- PACKED DECIMAL
- UNSIGNED NUMERIC
- ZONED NUMERIC

VAX BASIC supports only the PACKED DECIMAL decimal string data type, which corresponds to the VAX BASIC DECIMAL data type. For all other decimal string data types, VAX BASIC creates a group with the same name as the CDD/Plus subordinate field, and creates a string record component to contain the field. For example:

CDDL Definition

```
define record CDD$top.basic.decimalstring
    description is

        /* test decimal string data types */.

    decimalstring structure.
        my_packed_decimal          datatype is packed decimal
                                            size is 5 digits 2 fractions.
        my_zoned_numeric           datatype is zoned numeric
                                            size is 6 digits 2 fractions.
        my_unsigned_numeric        datatype is unsigned numeric
                                            size is 8 digits 4 fractions.
        my_lef_sep_numeric         datatype is left separate numeric
                                            size is 10 digits 3 fractions.
        my_left_ovpnch_numeric     datatype is left overpunched numeric
                                            size is 5 digits 2 fractions.
        my_right_sep_numeric       datatype is right separate numeric
                                            size is 3 digits 1 fractions.
        my_right_ovpnch_numeric    datatype is right overpunched numeric
                                            size is 4 digits 2 fractions.
    end decimalstring structure.
end decimalstring.
```

Translated RECORD Statement

```
1        %INCLUDE %FROM %CDD "CDD
$TOP.BASIC.DECIMALSTRING"
   C1            !  test decimal string data types
   C1            RECORD  DECIMALSTRING                ! UNSPECIFIED
   C1              DECIMAL(5 ,2 ) MY_PACKED_DECIMAL ! PACKED DECIMAL
   C1              GROUP   MY_ZONED_NUMERIC           ! ZONED NUMERIC !
   C1                STRING  STRING_VALUE  = 6
   C1              END GROUP
   C1              GROUP   MY_UNSIGNED_NUMERIC        ! UNSIGNED NUMERIC
   C1                STRING  STRING_VALUE  = 8
   C1              END GROUP
   C1              GROUP   MY_LEF_SEP_NUMERIC         ! NUMERIC LEFT
                                                      ! SEPARATE
   C1                STRING  STRING_VALUE  = 11
   C1              END GROUP
   C1              GROUP   MY_LEFT_OVPNCH_NUMERIC     ! NUMERIC LEFT
                                                      ! OVERPUNCHED
   C1                STRING  STRING_VALUE  = 5
   C1              END GROUP
   C1              GROUP   MY_RIGHT_SEP_NUMERIC       ! NUMERIC RIGHT
                                                      ! SEPARATE
   C1                STRING  STRING_VALUE  = 4
   C1              END GROUP
   C1              GROUP   MY_RIGHT_OVPNCH_NUMERIC    ! NUMERIC RIGHT
                                                      ! OVERPUNCHED
   C1                STRING  STRING_VALUE  = 4
   C1              END GROUP
   C1            END RECORD
%BASIC-I-CDDSUBGRO,          data type in CDD/Plus not supported,
           substituted group for: DECIMALSTRING::MY_ZONED_NUMERIC.
%BASIC-I-CDDSUBGRO,          data type in CDD/Plus not supported,
           substituted group for: DECIMALSTRING::MY_UNSIGNED_NUMERIC.
%BASIC-I-CDDSUBGRO,          data type in CDD/Plus not supported,
           substituted group for: DECIMALSTRING::MY_LEF_SEP_NUMERIC.
%BASIC-I-CDDSUBGRO,          data type in CDD/Plus not supported,
           substituted group for: DECIMALSTRING::MY_LEFT_OVPNCH_NUMERIC.
%BASIC-I-CDDSUBGRO,          data type in CDD/Plus not supported,
           substituted group for: DECIMALSTRING::MY_RIGHT_SEP_NUMERIC.
%BASIC-I-CDDSUBGRO,          data type in CDD/Plus not supported,
           substituted group for: DECIMALSTRING::MY_RIGHT_OVPNCH_NUMERIC.
```

23.9.5 Other Data Types

VAX CDD/Plus supports the following additional data types:

- BIT
- DATE
- POINTER
- UNSPECIFIED

- VIRTUAL
- ALPHABETIC

VAX BASIC does not support these data types. VAX BASIC translates these data types by signaling the informational message “Datatype in CDD/Plus not supported, substituted group for: <field name>”, and creates a group to contain the field. See Table 23–2 for a description of how VAX BASIC translates these data types.

If you extract a CDD/Plus definition that contains a BIT field, the field must be a multiple of 8 bits (1 byte). This means that the following field must be aligned on a byte boundary. If the following field is not aligned on a byte boundary, VAX BASIC signals the error “Field <name> from CDD/Plus has bit offset or length”.

Appendix A

Compile-Time Error Messages

This appendix describes compile-time and compiler command errors, their causes, and the user action required to correct them.

A.1 Compile-Time Errors

VAX BASIC diagnoses compile-time errors and:

- Indicates the program line that generated the error or errors.
- Displays this program line.
- Shows you the location of the error or errors and assigns a number to each location for future reference.
- Displays the mnemonic, statement number within the line, the location number as previously displayed, and the message text. This is repeated for each error in the line.

VAX BASIC repeats this procedure for each error diagnosed during compilation. The error message format for compile-time errors is:

```
%BASIC-<l>-<mnemonic>, <n>: <message>
```

<l>
Is a letter indicating the severity of the error. The severity indicator can be one of the following:

- I, indicating information
- W, indicating a warning
- E, indicating an error
- F, indicating a severe error

<mnemonic>
Is a 3- to 9-character string that identifies the error. Error messages in this appendix are alphabetized by this mnemonic.

<n>:
Is the nth error within the line's "picture."

<message>
Is the text of the error message.

For example:

```
Diagnostic on source line 1, listing line 1, BASIC line 10

        10 DECLARE REAL BYTE A, A
.......................1.......2

%BASIC-E-CONDATSPC, 1:   conflicting data type specifications
%BASIC-E-ILLMULDEF, 2:   illegal multiple definition of name A
```

This display tells you that two errors were detected on line 10; VAX BASIC displays the line containing the error, then prints a "picture" showing you where the errors were detected. In the example, the picture shows a 1 under the keyword BYTE and a 2 under the second occurrence of variable A. The following line shows you:

- The error mnemonic CONDATSPC
- Which error in the line's "picture" is referred to by the mnemonic
- The message associated with that error

In this case, the error message tells you that there are two contradictory data-type keywords in the statement. The next line shows you the same type of information for the second error; in this case, the compiler detected multiple declarations of variable A.

If a compilation causes an error of severity I or W, the compilation continues and produces an object module. If a compilation causes an error of severity E, the compilation continues but produces no object module. If a compilation causes an error of severity F, the compilation aborts immediately.

The following is an alphabetized list of compilation error messages:

ACTARGMUS, actual argument must be specified

> **Explanation:** ERROR - A DEF function reference contains a null argument, for example, FNA(1,,2).
>
> **User Action:** Specify all arguments when referencing a DEF function.

ALLOCSML, allocated area may be too small for section

Explanation: WARNING - A MAP or COMMON with the same name exists in more than one program module, and the first one encountered by the compiler is smaller than the subsequent ones.

User Action: VAX BASIC first allocates MAP and COMMON areas in the main program, then MAP and COMMON areas in subprograms, in the order in which they were loaded. Thus, you can avoid this error by loading modules with the largest MAP or COMMON first. However, it is better practice to make MAP and COMMON areas equal in size.

AMBRECCOM, ambiguous RECORD component

Explanation: ERROR - The program contains an ambiguous RECORD component reference, for example, A::D when both A::B::D and A::C::D exist.

User Action: Remove the ambiguity by fully specifying the record component.

AMPCONILL, & continuation is illegal after %INCLUDE directive

Explanation: ERROR - A program contains an %INCLUDE directive followed by an ampersand continuation to another statement. For example, the following is illegal:

```
2300    %INCLUDE %FROM %CDD "CDD$TOP.PERSONNEL.EMPLOYEE"  &
        GOTO 3000
```

Ampersand continuation of the %INCLUDE directive is legal, however.

User Action: Recode to eliminate the line continuation or use backslash continuation.

AMPCONREP, & continuation is illegal after %REPORT directive

Explanation: ERROR - A program contains a %REPORT directive followed by an ampersand continuation to another statement. For example, the following is illegal:

```
2300    %REPORT %DEPENDENCY "CDD$TOP.PERSONNEL.EMPLOYEE.COURSE_FORM"  &
        GOTO 3000
```

Ampersand continuation of the %REPORT directive itself is legal, however.

User Action: Recode to eliminate the line continuation or use backslash continuation.

ANSDEFMUS, ANSI DEF must be defined before reference

Explanation: ERROR - A program compiled with the /ANSI_STANDARD qualifier contains a reference to a DEF function before the function definition.

User Action: Renumber the line containing the function definition so that the definition precedes all references to the function.

ANSILNREQ, a line number is required on first line for ANSI

Explanation: ERROR - When you specify the /ANSI qualifier, a program must have a line number on the first line for the ANSI qualifier.

User Action: Supply a line number on the first line.

ANSKEYSPC, keywords must be delimited by spaces in /ANSI

Explanation: ERROR - A program compiled with the /ANSI_STANDARD qualifier contains a line where two elements (two keywords, a keyword and a line number, or a keyword and a string constant) are not separated by at least one space. For example, PRINT"Hello".

User Action: Delimit all keywords, line numbers, and string constants with at least one space.

ANSLINDIG, ANSI line number may not exceed 4 digits

Explanation: ERROR - A program compiled with the /ANSI_STANDARD qualifier contains a line number with more than 4 digits, that is, a number greater than 9999.

User Action: Renumber the program lines so that no line number exceeds 9999.

ANSLINNUM, ANSI line numbers must begin in column 1

Explanation: ERROR - A program compiled with the /ANSI_STANDARD qualifier contains a line number preceded by one or more spaces or tabs.

User Action: Remove any spaces and tabs that precede the line number.

ANSREQREA, ANSI requires REAL default type

Explanation: ERROR - The /ANSI_STANDARD qualifier conflicts with the /TYPE_DEFAULT qualifier.

User Action: Do not specify a default data type other than REAL. REAL is the default.

ANSREQSCA, ANSI requires SCALE 0

Explanation: ERROR - The /ANSI_STANDARD qualifier conflicts with the /SCALE qualifier.

User Action: Do not specify a scale factor.

ANSREQSET, ANSI requires SETUP

Explanation: ERROR - The /ANSI_STANDARD qualifier conflicts with the /NOSETUP qualifier.

User Action: Do not specify /NOSETUP.

ANYDIMNOT, dimension checking not allowed on ANY

Explanation: ERROR - Both a data type of ANY and a DIM clause were specified in an EXTERNAL statement.

User Action: Remove the DIM clause from the EXTERNAL statement. ANY implies either scalar or array.

ANYNOTALL, ANY not allowed on EXTERNAL PICTURE

Explanation: ERROR - An attempt was made to specify the ANY keyword on an EXTERNAL PICTURE declaration. This is not allowed because the ANY data type should be used for calling non-BASIC procedures only.

User Action: Remove the ANY keyword from the EXTERNAL PICTURE declaration.

APPMISNUM, append file missing line number on first line

Explanation: ERROR - An attempt was made to append a source file that does not contain a line number on the first line.

User Action: Put a line number on the first line of the appended file.

APPNOTALL, append not allowed on programs without line numbers

Explanation: ERROR - The APPEND command cannot be used on a program without line numbers.

User Action: Use an include file.

ARESTYMUS, area style must be "HOLLOW", "SOLID", "PATTERN", or "HATCH"

Explanation: ERROR - You specified an invalid value in the SET AREA STYLE statement.

User Action: Specify one of the values listed in the message.

AREREQTHR, AREA output requires at least 3 X,Y points

Explanation: ERROR - An AREA graphic output statement specifies less than 3 points.

User Action: Specify at least 3 points in the AREA graphic output statement.

ARGERR, illegal argument for command

Explanation: ERROR - An argument was entered for a command that does not take an argument, or an invalid argument was entered for a command, for example, SCALE A or LIST A.

User Action: Reenter the command with the proper arguments.

ARRMUSHAV, array must have 1 dimension

Explanation: ERROR - An array with multiple dimensions is specified where a 1-dimensional array is required.

User Action: Specify an array that has 1 dimension.

ARRMUSELE, array must have at least 4 elements

Explanation: ERROR - You specified an array with less than four elements. This statement requires an array with at least four elements in it.

User Action: Supply an array declared as having at least 4 elements.

ARRNAMREQ, array names only allowed

Explanation: ERROR - The type of variable name required must be an array name.

User Action: Change the variable name to an array name.

ARRNOTALL, array <name> not allowed in DEF declaration

Explanation: ERROR - The parameter list for a DEF function definition contained an entire array.

User Action: Remove the array specification. Passing an entire array as a parameter to a DEF function is not allowed.

ARRTOOBIG, named array <array-name> is too large

Explanation: ERROR - An array must occupy fewer than (2^16 – 1) bytes of storage.

User Action: Reduce the size of the array. If the array is within a record, the maximum size of the array is 65535 bytes.

ATROVRVAR, attributes of overlaid variable <name> don't match

Explanation: ERROR - A variable name appears in more than one overlaid MAP; however, the attributes specified for the variable are inconsistent.

User Action: If the same variable name appears in multiple overlaid MAPs, the attributes (for example, data type) must be identical.

ATRPRIREF, attributes of prior reference to <name> don't match

Explanation: WARNING - A variable or array is referenced before the MAP that declares it. The attributes of the referenced variable do not match those of the declaration.

User Action: Make sure that the variable or array has the same attributes in both the reference and the declaration.

ATTGTRZER, graphics attribute value must be greater than zero

Explanation: ERROR - You specified a negative value when a positive value is required.

User Action: Supply a value greater than zero.

BADFMTSTR, invalid PRINT USING format string

Explanation: ERROR - The PRINT USING format string specified is not valid.

User Action: Supply a valid PRINT USING format string.

BADLOGIC, internal logic error detected

Explanation: ERROR - An internal logic error was detected.

User Action: This error should never occur. Please submit a Software Performance Report with a machine-readable copy of the source program.

BADNO, qualifier <name> does not accept 'NO'

Explanation: ERROR - A qualifier that does not allow a 'NO' prefix was entered. For example, NODOUBLE.

User Action: Select the proper qualifier.

BADPROGNM, error in program name

Explanation: ERROR - The program name is longer than 39 characters or contains invalid characters.

User Action: Change the program name to be less than or equal to 39 characters and make sure that it contains only letters, digits, dollar signs, and underscores.

BADVALUE, <text> is an invalid keyword value

Explanation: FATAL - The command supplied an invalid value for a keyword.

User Action: Supply a valid value.

BASICHLB, BASIC's HELP library is not installed on this system

Explanation: INFORMATION - A HELP command was entered and the VAX BASIC BASIC HELP library was not available.

User Action: See your system manager.

BIFREQNUM, built in function requires numeric expression

Explanation: ERROR - A reference to a VAX BASIC built-in function contains a string instead of a numeric expression.

User Action: Supply a numeric expression.

BIFREQSTR, built in function requires string expression

Explanation: ERROR - The program specifies a numeric expression for a built-in function that requires a string argument.

User Action: Supply a string expression for the built-in function.

BLTFUNNOT, built in function not supported

Explanation: ERROR - The program contains a reference to a built-in function not supported by this version of VAX BASIC.

User Action: Remove the function reference.

BOTBOUSPE, bottom boundary must be less than the top boundary

Explanation: ERROR - In a statement that specifies a viewport or windowsize, you specified a bottom boundary that is greater than or equal to the corresponding top boundary.

User Action: Correct the bottom boundary so that it is less than the top boundary.

BOUCANNOT, bound cannot be specified for array

Explanation: ERROR - An EXTERNAL statement declaring a SUB or FUNCTION subprogram specifies bounds in an array parameter, for example:

```
EXTERNAL SUB XYZ (LONG DIM(1,2,3))
```

User Action: Remove the array parameter's bound specifications. When declaring an external subprogram, you can specify only the number of dimensions for an array parameter. For example:

```
EXTERNAL SUB XYZ (LONG DIM(,,))
```

BOUMUSTBE, bounds must be specified for array

Explanation: ERROR - The program contains an array declaration that does not specify the bounds (maximum subscript value). For example:

```
DECLARE LONG A(,)
```

User Action: Supply bounds for the declared array. For example:

```
DECLARE LONG A(50,50)
```

CANCON, can't continue

Explanation: FATAL - A CONTINUE command was typed after changes had been made to the source code.

User Action: After changes have been made to the source code, you can run the program, but you cannot continue it.

CAUNOTALL, CAUSE statement not allowed in error handler

Explanation: ERROR - A CAUSE statement is specified within an error handler.

User Action: Remove the CAUSE statement from the error handler.

CDDACCERR, CDD/Plus access error

Explanation: ERROR - CDD/Plus detected an error on an attempted CDD/Plus record extraction. VAX BASIC displays the CDD/Plus error.

User Action: Take action based on the associated CDD/Plus error.

CDDACCITE, CDD/Plus error while accessing item <field-name> of record

Explanation: ERROR - CDD/Plus reported an error when accessing the field. The CDD/Plus record definition is corrupt, or there is an internal error in either VAX BASIC or CDD/Plus.

User Action: If the problem is not in the CDD/Plus definition, please submit an SPR with the source code of a small program that produces this error.

CDDACCREC, CDD/Plus error while accessing record

Explanation: ERROR - CDD/Plus reported an error when accessing the record. The CDD/Plus record definition is corrupt or there is an internal error in either VAX BASIC or CDD/Plus.

User Action: If the problem is not in the CDD/Plus definition, please submit an SPR with the source code of a small program that produces this error.

CDDADJBOU, adjusted bounds for dimension <number> of <array> to be zero based

Explanation: INFORMATION - CDD/Plus contains an array field with a lower bound that is not zero. VAX BASIC adjusts the bound so that the array is zero based.

User Action: None.

CDDALCOFF, please submit an SPR—CDD/Plus inconsistent with allocated offset for <field-name>

Explanation: FATAL - The offset of a field within a VAX BASIC RECORD differs from the offset specified by CDD/Plus for that record.

User Action: Please submit an SPR with the source code of a small program that produces this error.

CDDALCSIZ, please submit an SPR—CDD/Plus inconsistent with allocated size for <field-name>

Explanation: FATAL - The amount of storage allocated for a field in a VAX BASIC RECORD differs from the amount specified by CDD/Plus for that record.

User Action: Please submit an SPR with the source code of a small program that produces this error.

CDDALCSPN, please submit an SPR—CDD/Plus inconsistent with allocated span for <field-name>

Explanation: FATAL - The amount of storage allocated by a VAX BASIC RECORD for an array differs from the amount specified by CDD/Plus for that record.

User Action: Please submit an SPR with the source code of a small program this error.

CDDAMBFLD, ambiguous field name <name> for <RECORD-name>

Explanation: ERROR - More than one CDDL structure share the same level and the same name.

User Action: Change the CDD/Plus definition so that the structures have different names.

CDDATTBAS, CDD/Plus attributes for <name> are other than base 10

Explanation: ERROR - A field in a CDD/Plus definition uses the BASE keyword. This warns you that the numeric field is not interpreted as a base 10 number.

User Action: Remove the BASE attribute in CDD/Plus or avoid using the field.

CDDATTDAT, CDD/Plus data type attribute not permitted for GROUP

Explanation: ERROR - A CDD/Plus definition specified a data type after the CDD/Plus STRUCTURE keyword. VAX BASIC translates STRUCTURE to a VAX BASIC RECORD or GROUP statement. These VAX BASIC statements do not allow data type attributes.

User Action: Change the CDD/Plus definition.

CDDATTDIG, DIGITS attribute of <field-name> not supported for datatype

Explanation: INFORMATION - The field contains a CDD/Plus fixed-point data type that specifies the number of allowed digits. This warning tells you that VAX BASIC interprets the field as BYTE, WORD, or LONG and does not support the DIGITS attribute for this data type.

User Action: None.

CDDATTSCA, CDD/Plus specifies SCALE for <RECORD-component>. Not supported.

Explanation: INFORMATION - A field in a CDD/Plus definition uses the SCALE keyword. This warns you that the field has an implied exponent.

User Action: Remove the SCALE attribute in CDD/Plus, or avoid using the field.

CDDATTTXT, CDD/Plus TEXT attribute for group <group-name> ignored

Explanation: INFORMATION - A CDD/Plus record definition specifies a data type of TEXT for the entire record.

User Action: None. VAX BASIC ignores the TEXT attribute and substitutes the UNSPECIFIED attribute.

CDDBASNAM, CDD/Plus specified BASIC name <name> has illegal form

Explanation: ERROR - The VAX BASIC name specified in the CDD/Plus record definition is a reserved keyword or contains an illegal character.

User Action: Change the invalid field name.

CDDBITFLD, field <field-name> from CDD/Plus has bit offset or length

Explanation: ERROR - A CDD/Plus field does not start on a byte boundary.

User Action: Change the bit field in CDD/Plus to have a length that is a multiple of 8 bits.

CDDCOLMAJ, <array-name> from CDD/Plus is a column major array

Explanation: ERROR - An array specified in a CDD/Plus definition is column-major rather than row-major. Thus, it is incompatible with VAX BASIC arrays.

User Action: Change the CDD/Plus definition to be a row-major array.

CDDDIGERR, decimal digits of <VALUE> in CDD/Plus out of range for <field-name>

Explanation: ERROR - A packed numeric CDD/Plus definition specifies more than 31 digits.

User Action: Reduce the number of digits specified in the CDD/Plus definition.

CDDDIMNOT, RECORD cannot be dimensioned

Explanation: ERROR - A CDD/Plus definition is itself an array. This is incompatible with VAX BASIC RECORDs, which can contain arrays but cannot be arrays.

User Action: None. You cannot access CDD/Plus definitions that are arrays.

CDDDUPREC, RECORD <name> from CDD/Plus has duplicate name

Explanation: ERROR - The CDD/Plus record name conflicts with a previous RECORD name. The previous RECORD name may be a standard VAX BASIC RECORD or another CDD/Plus record.

User Action: Remove one of the duplicate definitions.

CDDFLDNAM, field name missing

Explanation: ERROR - The CDD/Plus definition contains a field that is not named.

User Action: Supply a field name for the CDD/Plus definition.

CDDINTONLY, % not allowed on <name> with non-integer datatype

Explanation: ERROR - The % suffix is allowed only on numeric data types.

User Action: Remove the % suffix from the variable name or change the data-type keyword.

CDDLOWBOU, lower bound omitted for dimension <number> of <array-name>

Explanation: ERROR - An array in a CDD/Plus definition does not specify a lower bound.

User Action: Check to make sure the omission is not a mistake. VAX BASIC supplies a lower bound of zero and continues after issuing this warning.

CDDMAXDIM, <array-name> exceeds maximum dimensions

Explanation: ERROR - An array in a CDD/Plus definition specifies more than 32 dimensions.

User Action: Reduce the number of dimensions in the CDD/Plus definition.

CDDNAMKEY, <name> is a BASIC keyword

Explanation: ERROR - A CDD/Plus definition contains a field name that is a reserved word in VAX BASIC.

User Action: Change the name in the CDD/Plus definition or supply a VAX BASIC name clause.

CDDOCCIGN, OCCURS DEPENDING ON clause for <array-name> from CDD/Plus ignored

Explanation: INFORMATION - CDD/Plus contains an array field with a variable number of elements. VAX BASIC creates an array large enough for the maximum value.

User Action: If you modify the array field, be sure also to change the field that contains the number of array elements.

CDDOFFERR, CDD/Plus offset error, field <field-name> offsets out of order

Explanation: ERROR - The CDD/Plus definition has been corrupted or there is an internal error in either VAX BASIC or CDD/Plus.

User Action: If the problem is not in the CDD/Plus definition, please submit an SPR with the source code of a small program that produces this error.

CDDPLUSERR, CDD/Plus access error

Explanation: ERROR - CDD/Plus detected an error while attempting to record dependency data. VAX BASIC displays the CDD/Plus error.

User Action: Take action based on the associated CDD/Plus error.

CDDPREERR, decimal precision of <VALUE> in CDD/Plus out of range for <field-name>

Explanation: ERROR - The number of fractional digits for a packed decimal field is greater than the total number of digits specified for that field.

User Action: Change the number of fractional digits in CDD/Plus to be less than or equal to the total number of digits.

CDDRECFOR, CDD/Plus record format is not fixed

Explanation: ERROR - CDD/Plus supports both variable and fixed-length records. VAX BASIC supports only fixed-length records.

User Action: Change the CDD/Plus record definition to specify fixed-length.

CDDRECNAM, record from CDD/Plus does not have a record name

Explanation: ERROR - VAX BASIC uses the field name of the outermost structure to name the record, and therefore cannot include a CDD/Plus record that does not provide a record name.

User Action: Change the CDD/Plus record definition to provide a field name for the outermost structure of the record.

CDDSCAERR, decimal scale of <scale-factor> is out of range for <field> from CDD/Plus

Explanation: ERROR - The scale factor for a packed decimal CDD/Plus field is greater than the number of digits in the field or less than zero.

User Action: Change the scale factor in the CDD/Plus definition.

CDDSCAZER, scale 0 specified for CDD/Plus field <field-name>

Explanation: INFORMATION - A CDD/Plus field specifies no scale factor for a D_floating field, but the VAX BASIC program specifies a nonzero scale factor.

User Action: Use a scale factor of zero in the VAX BASIC program.

CDDSTRONLY, $ not allowed on <name> with non-string datatype

Explanation: ERROR - The $ suffix is only allowed on string data types.

User Action: Remove the $ suffix from the variable name or change the data-type keyword.

CDDSUBGRO, substituted GROUP for <field-name>. Data type in CDD/Plus not supported.

Explanation: INFORMATION - The CDD/Plus definition specifies a data type that is not native to VAX BASIC. VAX BASIC creates a GROUP with the same name as the CDD/Plus field and creates variable names for the GROUP components.

User Action: None.

CDDTAGIGN, tag value ignored for <field-name> from CDD/Plus

Explanation: INFORMATION - The CDD/Plus record definition contains a VARIANTS OF.

User Action: None. VAX BASIC translates the VARIANTS OF as if it were a regular variant; however, the tag value is ignored.

CDDUNSDAT, data type specified in CDD/Plus for <field-name> not supported

Explanation: ERROR - The data type specified for a field is not supported by VAX BASIC.

User Action: Change the data type in the CDD/Plus record definition.

CDDUPPBOU, upper bound omitted for dimension <number> of <array-name>

Explanation: ERROR - An array in a CDD/Plus definition does not specify an upper bound.

User Action: Specify an upper bound in the CDD/Plus definition.

CDDVARFLD, field <name> from CDD/Plus has variable offset or length

Explanation: ERROR - A CDD/Plus field can be either variable or fixed-length. VAX BASIC supports only fixed-length fields.

User Action: Change the CDD/Plus definition.

CHAEXPMUS, channel expression must be numeric

Explanation: ERROR - The program contains a nonnumeric channel expression, for example, PUT #A$

User Action: Change the channel expression to be numeric.

CHALINCLA, CHAIN does not support line number clause

Explanation: ERROR - A CHAIN statement contains a LINE keyword and a line number argument.

User Action: Remove the LINE keyword and the line number argument.

CHANGES, unsaved change has been made, CTRL/Z or EXIT to exit

Explanation: WARNING - A VAX BASIC source program in memory has been modified, and an EXIT command or CTRL/Z has been typed. VAX BASIC signals the error notifying you that if you exit from the compiler, the program modifications will be lost.

User Action: If you want to save the program, type SAVE. If you do not want to save the program, type EXIT or CTRL/Z.

CHANOTALL, CHANGES not allowed on primary key

Explanation: ERROR - The PRIMARY KEY clause in an OPEN statement specifies CHANGES.

User Action: Remove the CHANGES keyword; you cannot change the value of a primary key.

CHASTAAMB, CHANGE statement is ambiguous

Explanation: ERROR - A string variable and a numeric array have the same name in a CHANGE statement.

User Action: Change the name of the string variable or the numeric array.

CLIPMUSBE, clipping must be set to "ON" or "OFF"

Explanation: ERROR - You specified an invalid value in the SET CLIP statement.

User Action: Specify one of the values listed in the message.

CLOSEIN, error closing <file-name> as input

Explanation: ERROR - An error was detected while closing an input file.

User Action: Take corrective action based on the associated message.

CLOSEOUT, error closing <file-name> as output

Explanation: ERROR - An error was detected while closing an output file.

User Action: Take corrective action based on the associated message.

CMDNOTALL, command not allowed on programs without line numbers

Explanation: ERROR - A command that cannot be used on a program without line numbers has been used on a program without line numbers.

User Action: Do not use this command on programs without line numbers.

CODLENEST, internal code length estimate error. Submit an SPR

Explanation: FATAL - VAX BASIC has incorrectly estimated the size of the generated code for your program.

User Action: Submit an SPR with the program that caused the error. (You can often work around this error by making a simple change to your code.)

COLOUTRAN, color intensities must be in the range 0.0 to 1.0

Explanation: ERROR - The value specified for color intensity is either less than 0.0 or greater than 1.0.

User Action: Supply a value between 0.0 and 1.0.

COMMAPALI, variable <name> not aligned in COMMON/MAP <name>

Explanation: INFORMATION - In a COMMON or MAP, the total storage preceding a REAL, WORD, or LONG numeric variable is an odd number of bytes.

User Action: None. In VAX BASIC, numeric data can start on any byte boundary.

COMMAPNEQ, COMMON/MAP area sizes are not equal for section

Explanation: WARNING - A MAP or COMMON with the same name exists in more than one program module, but the size of the areas differs.

User Action: Make the size of the COMMON or MAP areas equal in size in all modules.

COMMAPOVF, COM/MAP <name> is too large

Explanation: ERROR - The program contains a MAP or COMMON longer than (2^31 – 1) longwords.

User Action: Reduce the length of the COMMON or MAP.

CONCOMSYN, conditional compilation cannot be used with /SYNTAX

Explanation: FATAL - The /SYNTAX_CHECKING qualifier is in effect when a program line containing the %IF, %THEN, %ELSE, or %END %IF lexical directive was entered.

User Action: Turn off syntax checking before entering a program line containing the %IF, %THEN, %ELSE, or %END %IF lexical directive.

CONDATSPC, conflicting data type specifications

Explanation: ERROR - The program contains a declarative statement containing two or more consecutive and contradictory data-type keywords, for example, DECLARE REAL BYTE.

User Action: Remove one of the data-type keywords or make sure that the keywords refer to the same generic data type. For example, DECLARE REAL SINGLE is valid.

CONEXPREQ, constant expression required

Explanation: ERROR - A statement specifies a variable, built-in function reference or exponentiation where a constant is required.

User Action: Supply an expression containing only literals or declared constants or remove the exponentiation operation.

CONTARNOT, CONTINUE target not legal in detached error handlers

Explanation: ERROR - A CONTINUE statement within a detached WHEN block error handler contains a target.

User Action: Remove the target line number or label from the CONTINUE statement or use an attached error handler.

CONIS_INC, constant is inconsistent with the type of <name>

Explanation: ERROR - A DECLARE CONSTANT statement specifies a value that is inconsistent with the data type of the constant, for example, a BYTE value specified for a REAL constant.

User Action: Change the declaration so that the data type of the value matches that of the constant.

CONIS_NEE, <item> requires conditional expression

Explanation: ERROR - A CASE or IF keyword is immediately followed by a floating-point or string expression.

User Action: Supply a conditional expression (relational, logical, or integer).

CONLFTSID, constant <name> not allowed on left side of assignment

Explanation: ERROR - The program tries to assign a value to a user-defined constant.

User Action: Remove the assignment statement; once you have assigned a value to a declared constant, you cannot change it.

CONNOTALL, constant <name> not allowed in assignment context

Explanation: ERROR - The program tries to assign a value to a user-defined constant.

User Action: Remove the assignment statement; once you have assigned a value to a declared constant, you cannot change it.

COOMUSBE, coordinates must be within NDC space (0.0 to 1.0)

Explanation: ERROR - The value of a coordinate is either less than 0.0 or greater than 1.0.

User Action: Supply a value between 0.0 and 1.0.

CORSTAFRA, corrupted stack frame

Explanation: ERROR - An immediate mode statement was entered after a STOP statement was executed in the BASIC environment and something corrupted the stack.

User Action: Check program logic to make sure that all array references are within array bounds. This error can also be caused by loading non-BASIC object modules in the BASIC environment.

COUONLALO, COUNT clause only allowed with array LIST clause

Explanation: ERROR - A COUNT clause was found on a SET INITIAL CHOICE statement that contains a LIST clause that does not contain a string array.

User Action: Remove the COUNT clause or use the array form of the LIST clause.

COUVALCAN, COUNT value cannot be greater than array size

Explanation: ERROR - In the COUNT clause, you specified a count that is larger than the size of the array that you supplied.

User Action: Change either the COUNT value or the size of the array so that COUNT is less than or equal to the number of elements in the array.

DATTYPEXP, data type required for variable <name> with /EXPLICIT

Explanation: ERROR - A program compiled with the /TYPE=EXPLICIT qualifier declares a variable without specifying a data type.

User Action: Supply a data-type keyword for the variable or compile the program without the /TYPE=EXPLICIT qualifier.

DATTYPNOT, data type keyword not allowed in SUB statement

Explanation: ERROR - A SUB statement contains a data-type keyword between the subprogram name and the parameter list.

User Action: Remove the data-type keyword. In a SUB statement, data-type keywords can appear only within the parameter list.

DATTYPREQ, data type required in EXTERNAL CONSTANT declaration

Explanation: ERROR - An EXTERNAL CONSTANT statement has no data-type keyword.

User Action: Supply a data-type keyword to specify the data type of the external constant.

DECIMERR, DECIMAL overflow

Explanation: WARNING - The program contains a DECIMAL expression whose value is outside the valid range.

User Action: Reduce the value of the DECIMAL expression.

DECLEXSYN, DECLARED lexical function syntax error

Explanation: ERROR - The syntax of the %DECLARED lexical function is specified incorrectly.

User Action: Supply the correct syntax.

DECPREOUT, DECIMAL precision specification out of range

Explanation: ERROR - In the declaration for a packed decimal variable or constant, the number of digits to the right of the decimal point is greater than the total number of digits specified, or greater than 31.

User Action: Change the declaration so that the total number of digits specified is less than 31, and the number of digits to the right of the decimal point is less than or equal to the total number of digits.

DECSIZOUT, DECIMAL size specification out of range

Explanation: ERROR - The declaration for a packed decimal variable or variable specifies more than 31 digits.

User Action: Change the declaration to specify 31 or fewer digits.

DEFINVNOT, DEF invocation not allowed in assignment context

Explanation: ERROR - A DEF function invocation (including a parameter list) appears on the left side of an assignment statement.

User Action: Remove the assignment statement. You cannot assign values to a function invocation.

DEFMODNOT, DEF <name> mode not as declared

Explanation: ERROR - The specified data type in a function declaration disagrees with the data type specified in the function definition.

User Action: Make the data-type specifications match in both the function declaration and the function definition.

DEFNOTDEF, DEF <name> not defined

Explanation: ERROR - The program contains a reference to a nonexistent user-defined function.

User Action: Define the function in a DEF statement.

DEFNOTWHE, DEF not allowed in WHEN block or handler

Explanation: ERROR - A DEF function definition is not allowed in a WHEN block or its associated handler.

User Action: Remove the DEF function definition from within the WHEN block or handler.

DEFRESREF, DEF <name> result reference illegal in this context

Explanation: ERROR - The program attempts to assign a value to a DEF name outside the DEF block.

User Action: Remove the assignment statement. You cannot assign a value to a DEF outside of the DEF block.

DEFSIZNOT, DEF <name> decimal size not as declared

Explanation: ERROR - The DECIMAL(d,s) size specified in the DEF statement does not match the DECIMAL(d,s) used in the associated DECLARE DEF statement.

User Action: Make the DECIMAL size specification agree in both the DECLARE DEF and DEF statements.

DEFSTAPAR, DEF* formal <formal-name> inconsistent with usage outside DEF*

Explanation: ERROR - A DEF* formal parameter has the same name as a program variable, but different attributes.

User Action: You should not use the same names for DEF* parameters or program variables. If you do, you must ensure that they have the same data type and size.

DEFSTRPAR, DEF string parameter is illegal in MAP DYNAMIC or REMAP

Explanation: ERROR - You cannot use a static string that is a parameter declared in a DEF or DEF* function as the storage area in a MAP DYNAMIC or REMAP statement.

User Action: Change the storage area specification in the MAP DYNAMIC or REMAP statement to use either a MAP name or a static string variable that is not a parameter to the DEF or DEF* function.

DELETE, ignoring <item>

Explanation: ERROR - The program contains a syntax error. The compiler tries to recover from the error by ignoring an operator or separator in the source line. For example, DIM A(3,) is a syntax error, but VAX BASIC continues the compilation by ignoring the comma. The compilation continues only in order to discover other errors; no object module is produced.

User Action: Correct the syntax error in the displayed line.

DEPNOTANS, /DEPENDENCY_DATA qualifier not allowed with /ANSI

Explanation: ERROR - The /DEPENDENCY_DATA qualifier conflicts with the /ANSI_STANDARD qualifier.

User Action: Specify either the /DEPENDENCY_DATA qualifier or the /ANSI_STANDARD qualifier, but not both.

DESCOMABORT, /DESIGN=COMMENT processing has been aborted due to an internal error - please submit an SPR

Explanation: INFORMATION - The compiler was unable to process comment information due to an internal error. Submit an SPR.

User Action: Please submit an SPR with the source code of a small program that produces the error.

DESCOMERR, error in processing design information

Explanation: WARNING - The design information was syntactically incorrect.

User Action: You should respecify the design information and compile the program again.

DESIGNTOOOLD, /DESIGN=COMMENT processing routines are too old for the compiler

Explanation: WARNING - The compiler encountered obsolete routines.

User Action: Install a new version of the VAX Language-Sensitive Editor.

DESOUTRAN, destination out of range

Explanation: FATAL - The branch destination in an ON GOSUB statement is greater than 32767 bytes away from the statement.

User Action: Reduce the distance between the destination and the statement.

DIMOUTRAN, dimension is out of range

Explanation: ERROR - The program contains the declaration of an array that specifies a negative number as a dimension.

User Action: Change the dimension to a positive number.

DIMLSSZERO, dimension must be greater than zero

Explanation: ERROR - The number specified for a dimension must be greater than zero.

User Action: Change the number to be greater than zero.

DIMTOOBIG, dimension for array <name> must be between 1 and <number>

Explanation: ERROR - The number of the dimension specified is greater than the number of dimensions in the array.

User Action: Change the dimension number to be less than or equal to the number of dimensions in the array.

DIRMUSTBE, directive must be only item on line

Explanation: ERROR - The program contains a compiler directive that is not the only item on the line.

User Action: Place the directive on its own line.

DIRNOTIMM, directive not valid in immediate mode

Explanation: ERROR - A compiler directive was typed in the BASIC environment.

User Action: None. Compiler directives are invalid in immediate mode.

DIVBY_ZER, division by zero

Explanation: WARNING - The value of a number divided by zero is indeterminate.

User Action: Change the expression so that no expression is divided by the constant zero.

DRAWITREQ, DRAW WITH clause requires 4X4 matrix

Explanation: ERROR - A user matrix is specified in a DRAW statement WITH clause where a 2-dimensional matrix with lower bounds 0 and upper bounds 4 in both dimensions is required.

User Action: Declare the matrix to be a 2-dimensional matrix with lower bounds 0 and upper bounds 4 in both dimensions.

DUPCLASPE, duplicate clause specified

Explanation: ERROR - A duplicate clause was found on a SET INITIAL statement or a graphics input statement.

User Action: Remove the duplicate clause.

DUPLINNOT, duplicate line numbers not ANSI

Explanation: ERROR - A program compiled with the /ANSI_STANDARD qualifier from the DCL command level, or called into the BASIC environment with the OLD command while the /ANSI_STANDARD qualifier is in effect, contains two identical line numbers.

User Action: Remove one instance of the duplicate line number. Even if you compile the program without the /ANSI_STANDARD, VAX BASIC will ignore all statements connected with the first instance of the duplicate line number before compiling the program.

DUPLNFND, duplicate line number <number> found

Explanation: INFORMATION or WARNING

Explanation: INFORMATION - A line number in an include file is the same as a line number in the main source file.

Explanation: WARNING - There are two lines in the main source file with the same line number. VAX BASIC keeps the second occurrence of the line number.

User Action: Correct the source by changing one of the line numbers to an unused number.

DYNATTONL, DYNAMIC attribute only valid for MAP areas

Explanation: ERROR - A COMMON keyword is followed by the DYNAMIC keyword.

User Action: Remove the DYNAMIC keyword. The DYNAMIC attribute is valid only for MAP areas.

DYNSTRINH, dynamic string variable <name> inhibits optimization

Explanation: INFORMATION - This error is reported only when the /NOSETUP qualifier is in effect. The program contains a dynamic string variable. This prevents optimization of the compiler-generated code.

User Action: Place the string variable in a COMMON keyword or MAP area.

ELSIMPCON, ELSE appears in improper context, ignored

Explanation: ERROR - The program contains an ELSE clause that either is not preceded by an IF statement or that appears after an IF has been terminated with a line number or END IF.

User Action: Remove either the ELSE clause or the terminating line number or END IF.

ENDIMPCON, END IF appears in improper context, ignored

Explanation: ERROR - The program contains an END IF statement that either is not preceded by an IF statement or occurs after an IF has been terminated by a line number.

User Action: Supply an IF statement or remove the terminating line number.

ENDSTAREQ, END statement required in ANSI

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier does not contain an END statement.

User Action: Include an END statement as the last statement in the program. ANSI Minimal BASIC requires an END statement.

ENTARRFIE, entire array field of virtual record cannot be passed

Explanation: ERROR - The program attempts to pass an entire array as a parameter to a subprogram when:

- The array is an item in a record
- The record is itself dimensioned as a virtual array

User Action: Assign the values of the array to another array that is of the same data type and dimension but that is not a field of a virtual array record, and pass the second array as the parameter.

ENTARRNOT, entire array not allowed in this context

Explanation: ERROR - The program specifies an entire array in a context that permits only array elements, for example, in a PRINT statement.

User Action: Remove the reference to the entire array.

ENTGRONOT, entire GROUP or RECORD not allowed in this context

Explanation: ERROR - The program specifies an entire GROUP or RECORD in a context that permits only GROUP or RECORD components, for example, PRINT ABC::XYZ where XYZ is a GROUP.

User Action: Remove the reference to the entire GROUP or RECORD.

ENTVIRARR, entire virtual array cannot be a parameter

Explanation: ERROR - The program attempts to pass an entire virtual array as a parameter.

User Action: None. You cannot pass an entire virtual array as a parameter.

EOLNOTTER, End of line does not terminate IFs due to active blocks

Explanation: ERROR - A THEN or ELSE clause contains a loop block, and a line number terminates the IF-THEN-ELSE before the end of the loop block.

User Action: Make sure that any loop is entirely contained in the THEN or ELSE clause.

ERLNOTALL, ERL statement not allowed in programs without line numbers

Explanation: ERROR - An ERL statement has been found in a program without line numbers.

User Action: Remove the ERL statement.

ERRACCLIB, error accessing module <mod-name> in text library <text-lib-name>

Explanation: ERROR - VAX BASIC found an unexpected LIBRARIAN error while trying to %INCLUDE a text library module. This error message is followed by a specific LIBRARIAN (LBR) message.

User Action: Take appropriate action based on the associated LBR message.

ERRCLOLIB, error closing text library <text-lib-name>

Explanation: ERROR - The text library specified in an %INCLUDE directive could not be closed. This error message is followed by the specific LIBRARIAN (LBR) error.

User Action: Take appropriate action based on the associated LBR message.

ERROPEFIL, error opening file

Explanation: ERROR - The file specified in a %INCLUDE directive could not be opened. This error message is followed by the specific RMS error.

User Action: Take appropriate action based on the associated RMS error.

ERROPELIB, error opening text library <text-lib-name>

Explanation: ERROR - The text library specified in an %INCLUDE directive could not be opened. This error message is followed by the specific LIBRARIAN (LBR) error.

User Action: Take appropriate action based on the associated LBR message.

ERRRECCOM, erroneous RECORD component

Explanation: ERROR - The program contains an erroneous record component, for example, specifying A::B when RECORD A has no component named B.

User Action: Remove the erroneous reference.

EXEDIMILL, executable DIMENSION illegal for static array

Explanation: ERROR - A DIMENSION statement names an array already declared with a DECLARE, COMMON, MAP, or RECORD statement, or one that was declared statically in a previous DIMENSION statement.

User Action: Remove the executable DIMENSION statement or originally declare the array as executable in a DIMENSION statement.

EXPDECREQ, explicit declaration of <name> required

Explanation: ERROR - The program is compiled with the /TYPE:EXPLICIT qualifier in effect, and the program references a variable, constant, function, or subprogram name that is not explicitly declared.

User Action: Explicitly declare the variable, constant, function, or subprogram.

EXPIFDIR, expecting IF directive

Explanation: ERROR - The program contains a %END that is not immediately followed by a %IF.

User Action: Supply a %IF immediately following the %END.

EXPNOTALL, expression not allowed in this context

Explanation: ERROR - The program contains an expression in a context that allows only simple variables, array elements, or entire arrays, for example, in FIELD and MOVE statements.

User Action: Remove the expression.

EXPTOOCOM, expression too complicated

Explanation: ERROR - The program contains an expression or statement too complicated to compile. This message can occur whenever VAX BASIC is unable to allocate sufficient registers.

User Action: Recode as required; for example, rewrite the statement as two or more less complicated statements.

EXPUNAOPE, expecting unary operator or legal lexical operand

Explanation: ERROR - A compiler directive contains an invalid lexical expression, for example, %IF *3% %THEN.

User Action: Correct the lexical expression.

EXTELSFOU, extra ELSE directive found

Explanation: ERROR - The program contains a %ELSE directive that is not matched with a %IF directive.

User Action: Make sure that each %ELSE is preceded by a %IF, and that each %IF contains no more than one %ELSE clause.

EXTENDIF, extra END IF directive found

Explanation: ERROR - A program unit contains a %END %IF without a preceding %IF directive.

User Action: Supply a %IF for the %END %IF.

EXTLEFPAR, extra left parenthesis in expression

Explanation: ERROR - A compiler directive contains a lexical expression with an extra left parenthesis.

User Action: Remove the extra parenthesis.

EXTNAMTOO, EXTERNAL name too long, truncating to <new-name>

Explanation: WARNING - An EXTERNAL statement names a symbol longer than 31 characters.

User Action: Shorten the symbol name to 31 characters or less.

EXTRIGPAR, extra right parenthesis in expression.

Explanation: ERROR - A compiler directive contains a lexical expression with an extra right parenthesis.

User Action: Remove the extra parenthesis.

EXTSTRVAR, EXTERNAL STRING variables not supported

Explanation: ERROR - The program contains an EXTERNAL statement that specifies an external string variable.

User Action: Remove or change the EXTERNAL statement. VAX BASIC does not support external string variables.

FEANOTANS, language feature not ANSI

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier contains a VAX BASIC feature (such as a long variable name or a string array) that does not conform to the ANSI Minimal BASIC Standard. (See Chapter 7 for more information on the ANSI Minimal Standard.)

User Action: Although VAX BASIC allows you to run programs with non-ANSI language features, you must remove these features if you want your program to be transportable to other ANSI Minimal BASIC compilers.

FIEVALONL, FIELD valid only for dynamic string variables

Explanation: ERROR - A FIELD statement contains a numeric or fixed-length string variable.

User Action: Remove the numeric or fixed-length string variable. Only dynamic string variables are valid in FIELD statements.

FILACCERR, file access error for INCLUDE directive <file-name>

Explanation: ERROR - The file named in the %INCLUDE directive was correctly opened but could not be read for some reason, for example, the disk drive was switched off line.

User Action: Take action based on the associated RMS error messages.

FILEWRITE, <prog-name> written to file: <file-name>

Explanation: INFORMATION - The specified program name has been saved in file-name.

User Action: None.

FILNOTALL, FILL not allowed in MAP DYNAMIC

Explanation: ERROR - A MAP DYNAMIC statement contains a FILL item.

User Action: Remove the FILL item.

FILNOTDEL, error deleting <file-name>

Explanation: ERROR - An error was detected in attempting to delete a file.

User Action: Supply a valid file specification, or take corrective action based on the associated message.

FILTOOBIG, FILL number <n> in overlay <m> of MAP <name> too big

Explanation: ERROR - A FILL string length or repeat count caused the compiler to try to allocate more than 2^31 longwords of storage.

User Action: Check the specified MAP statement and change the FILL string length or repeat count.

FLOCVTILL, floating CVT valid only for SINGLE and DOUBLE

Explanation: ERROR - A CVTF$ or CVT$F function names a GFLOAT or HFLOAT value as an argument.

User Action: Use a SINGLE or DOUBLE argument rather than GFLOAT or HFLOAT.

FLOPOIERR, floating point error or overflow

Explanation: WARNING - The program contains a numeric expression whose value is outside the valid range for the default floating-point data type.

User Action: Modify the expression so that its value is within the allowable range or select as the default REAL size a floating-point data type that has a greater range.

FNEWHINOT, exit from DEF while not in DEF

Explanation: ERROR - An FNEXIT or EXIT DEF statement has no preceding DEF statement.

User Action: Define the function before inserting an FNEXIT or EXIT DEF statement.

FNEWITDEF, end of DEF seen while not in DEF

Explanation: ERROR - An FNEND or END DEF statement has no preceding DEF statement.

User Action: Define the function before inserting an FNEND statement or delete the FNEND statement.

FORFEEMUS, FORM FEED must appear at end of line

Explanation: INFORMATION - A form-feed character is followed by other characters in the same line.

User Action: Remove the characters following the form feed. A form feed must be the last or only character on a line.

FORPARMUS, formal parameter must be supplied for <name>

Explanation: ERROR - The declaration of a DEF, SUB, or FUNCTION routine contains the parentheses for a parameter list but no parameters.

User Action: Supply a parameter list or remove the parentheses.

FORSTRPAR, formal string parameters may not be FIELDed

Explanation: ERROR - A variable name appears both in a subprogram formal parameter list and a FIELD statement in the subprogram.

User Action: Remove the variable from the FIELD statement or the parameter list.

FOUENDWIT, found end of <block> without matching <item>

Explanation: ERROR - The program contains an END SELECT, END DEF, END FUNCTION, FUNCTIONEND, SUBEND, END SUB, or END IF without a matching SELECT, DEF, SUB, FUNCTION, or IF.

User Action: Supply a SELECT, DEF, FUNCTION, SUB, or IF to match the END <block> statement, or remove the erroneous END statement.

FOUND, found <item> when expecting <item>

Explanation: ERROR - The program contains a syntax error. VAX BASIC displays the item where the error was detected, then displays one or more items that make more sense in that context. The compilation continues so that other errors may be detected. The actual program line remains unchanged and no object file is produced.

User Action: Examine the line carefully to discover the error. Change the program line to correct the syntax error.

FOUNXTWIT, found NEXT without matching WHILE or UNTIL

Explanation: ERROR - The program contains a NEXT statement without a corresponding WHILE or UNTIL statement.

User Action: Supply a WHILE or UNTIL statement or remove the erroneous NEXT statement.

FOUWITMAT, found NEXT without matching FOR

Explanation: ERROR - The program contains a NEXT <control-variable> statement without a matching FOR <control-variable> statement.

User Action: Supply a FOR statement or remove the erroneous NEXT statement.

FUNINVNOT, function invocation not allowed in assignment context

Explanation: ERROR - An external function invocation (including a parameter list) appears on the left side of an assignment statement.

User Action: Remove the assignment statement. You cannot assign values to a function invocation.

FUNNESTOO, function nested too deep

Explanation: ERROR - The program contains too many levels of function definitions within function definitions.

User Action: Reduce the number of nested functions.

FUNWHINOT, exit from FUNCTION while not in FUNCTION

Explanation: ERROR - An EXIT FUNCTION or FUNCTIONEXIT statement was found in a module that is not a FUNCTION subprogram.

User Action: Remove the EXIT FUNCTION or FUNCTIONEXIT statement.

GRAARRMUS, graphics array must be integer or real

Explanation: ERROR - The specified array has a data type other than an integer or real data type.

User Action: Declare the array with an integer or real data type.

HANNOTDEF, HANDLER not allowed in DEF

Explanation: ERROR - A HANDLER definition has been found within a DEF function definition.

User Action: Remove the HANDLER definition from inside the DEF function definition.

HANNOTFOU, error handler <name> not found

Explanation: ERROR - You did not define the HANDLER you referenced in a WHEN statement.

User Action: Define the HANDLER you reference in the WHEN statement.

HANNOTWHE, HANDLER not allowed in a WHEN block or handler

Explanation: ERROR - A detached HANDLER definition was found in a WHEN block protected region or associated handler.

User Action: Remove the HANDLER definition from within all WHEN block protected regions and associated handlers.

HANWHINOT, exit from HANDLER while not in HANDLER

Explanation: ERROR - An EXIT HANDLER statement was found while not in a HANDLER block.

User Action: Remove the EXIT HANDLER statement.

HORJUSMUS, horizontal justification must be "LEFT", "CENTER", "RIGHT" or "NORMAL"

Explanation: ERROR - You specified an invalid value for the horizontal component of the SET TEXT JUSTIFY statement.

User Action: Specify one of the values listed in the message.

IDEMAYAPP, IDENT directive may appear only once per module

Explanation: WARNING - The program contains more than one %IDENT compiler directive.

User Action: Remove all but one %IDENT directive.

IDENAMTOO, IDENT directive name is too long

Explanation: WARNING - The quoted string in a %IDENT directive is too long.

User Action: Reduce the length of the string. The maximum length is 31 characters.

IF_EXPMUS, IF directive expression must be terminated by THEN directive

Explanation: ERROR - A %IF directive contains a %ELSE clause with no intervening %THEN clause.

User Action: Insert a %THEN clause.

IF_IN_INC, IF directive in INCLUDE directive needs END IF directive in same file

Explanation: ERROR - A %INCLUDE file contains a %IF but no %END %IF.

User Action: Supply a %END %IF for the %INCLUDE file.

IF_NOTTER, IF statement not terminated

Explanation: ERROR - The program contains an IF-THEN-ELSE statement within a block (for example, a FOR-NEXT, SELECT-CASE, or WHILE block) and the end of the block was reached before the IF-THEN-ELSE statement was terminated.

User Action: Check program logic to be sure IF-THEN-ELSE statements are terminated with a line number or an END IF statement before the end of the block is reached.

ILLALLCLA, illegal ALLOW clause <clause>

Explanation: ERROR - The program contains an ALLOW clause on a GET statement, and the file was not opened with the UNLOCK EXPLICIT clause.

User Action: Either remove the ALLOW clause from the GET statement or use the UNLOCK EXPLICIT clause in the OPEN statement.

ILLARGBP2, illegal argument count for BP2

Explanation: INFORMATION - The program contains a SUB, DEF, or EXTERNAL FUNCTION reference with more than 32 parameters. This error is reported only when the /FLAG:BP2COMPATIBILITY qualifier is in effect.

User Action: If the program must run under both VAX BASIC and PDP–11 BASIC-PLUS-2, the function must have 32 or fewer parameters.

ILLARGPAS, illegal argument passing mechanism

Explanation: ERROR - The program specifies an invalid argument-passing mechanism. For example, passing strings or arrays BY VALUE, or passing an entire virtual array.

User Action: Check all elements for the proper parameter-passing mechanism.

ILLCALFUN, illegal CALL of a DECIMAL, HFLOAT or STRING function

Explanation: ERROR - You attempted to use the CALL statement to invoke either a DECIMAL, HFLOAT, or STRING function.

User Action: Invoke the function not using the CALL statement.

ILLCHA, illegal character <ASCII code>

Explanation: WARNING - The program contains illegal or incorrect characters.

User Action: Examine the program for correct usage of the VAX BASIC character set and possibly delete the character.

ILLCHAEXT, illegal character <ASCII code> in external name

Explanation: ERROR - The external symbol in an EXTERNAL FUNCTION or CONSTANT declaration contains an invalid character.

User Action: Remove the invalid character. External names can use only printable ASCII characters: ASCII values in the range 32 to 126, inclusive.

ILLCHAIDE, illegal character <ASCII value> in IDENT directive

Explanation: WARNING - A %IDENT directive contains an illegal character with the reported ASCII value.

User Action: Remove the illegal character.

ILLCONTYP, illegal constant type

Explanation: ERROR - The program contains an invalid declaration, for example, DECLARE RFA CONSTANT.

User Action: Remove the invalid data type. You cannot declare constants of the RFA data type.

ILLEXTPDP, <name> is illegal as a PDP–11 external name

Explanation: INFORMATION - This error is reported only when the /FLAG:BP2COMPATIBILITY qualifier is in effect. The external name is longer than six characters or contains a non-RAD50 character.

User Action: Reduce the length of the name or remove the non-RAD50 character.

ILLFRMNAM, illegally formed name

Explanation: ERROR - The program contains an invalid user identifier (such as a variable, constant, or function name).

User Action: Change the name to comply with the rules for naming user identifiers. See the *VAX BASIC Reference Manual* for more information.

ILLFRMNUM, illegally formed numeric constant

Explanation: ERROR - The program contains either: 1) an invalid E-format expression, or 2) a numeric constant with a digit that is invalid in the specified radix, for example, a decimal constant containing a hexadecimal digit.

User Action: Supply a valid E-format expression or a constant that is valid in the specified radix.

ILLGOTO, can't GOTO outside current procedure

Explanation: WARNING - The target line number of an immediate mode GOTO statement is outside of the currently compiled procedure.

User Action: None. If you RUN a source file containing more than one program unit, the currently compiled program is the last program unit in the source file. If you use the OLD command to read a program into memory and load one or more object modules, then type RUN, the currently compiled procedure is the program you read into memory with OLD.

ILLIDEPDP, illegal %IDENT string for PDP–11

Explanation: INFORMATION - A %IDENT compiler directive contains a string that is invalid for PDP–11 systems. This error is issued only when the BP2 compatibility flagger is enabled.

User Action: Change the %IDENT string. The string must be between 1 and 6 characters, and must contain only RAD-50 characters.

ILLIO_CHA, illegal I/O channel

Explanation: ERROR - A constant channel expression is greater than 99, or a variable channel expression is greater than 119.

User Action: If the channel expression is a constant, change to be less than or equal to 99. A variable channel expression can be less than or equal to 119; however, channels in the range 100 through 119 are reserved for programs using LIB$GET_LUN.

ILLLINNUM, illegal line number in CHAIN

Explanation: ERROR - A CHAIN with LINE statement specifies an invalid line number. Either the number is outside the valid range, or a string expression follows the LINE keyword.

User Action: Supply an integer line number between 1 and 32767, inclusive.

ILLLOCARG, illegal LOC argument

Explanation: ERROR - An argument to the LOC function is a constant, virtual array element, or expression.

User Action: Change the argument to the LOC function.

ILLLOONES, illegal loop nesting, expecting NEXT <VARIABLE>

Explanation: ERROR - The program contains overlapping loops.

User Action: Examine the program logic to make sure that the FOR and NEXT statements for the inside loop lie entirely within the outside loop.

ILLMATOPE, illegal matrix operation

Explanation: ERROR - The program attempts matrix division. The operation is treated as a MAT multiply, and the compilation continues.

User Action: Remove the attempted matrix division. VAX BASIC does not support this operation.

ILLMCHPDP, illegal passing mechanism on PDP–11s

Explanation: INFORMATION - This error is reported only when the /FLAG:BP2COMPATIBILITY qualifier is in effect. A parameter list contains a BY clause that is invalid in PDP–11 BASIC-PLUS-2, for example, specifying BY DESC for parameters that are not entire arrays or strings.

User Action: See the *VAX BASIC Reference Manual* for allowable BASIC-PLUS-2 parameter-passing mechanisms.

ILLMIDLEN, illegal MID assignment length

Explanation: ERROR - The value of the length in the MID statement is either greater than the length of the string or less than or equal to zero.

User Action: Correct the length to be between 1 and the length of the string.

ILLMIDSTRT, illegal MID starting value

Explanation: ERROR - The starting value in the MID statement is less than or equal to zero.

User Action: Correct the starting value to be greater than or equal to one.

ILLMODMIX, illegal mode mixing

Explanation: ERROR - The program contains string and numeric operands in the same operation.

User Action: Change the expression so that it contains either string or numeric operands, but not both.

ILLMULDEF, illegal multiple definition of name <name>

Explanation: ERROR - The program uses the same name for:

- More than one variable
- A variable and a MAP
- A variable and a COMMON
- A MAP and COMMON

User Action: Use unique names for variables, COMMONs, and MAPs.

ILLMULOPT, OPTIONAL cannot be specified more than once

Explanation: ERROR - The OPTIONAL clause was specified more than once in the EXTERNAL statement for a single SUB or FUNCTION. This is not allowed because OPTIONAL implies that all parameters following it are optional.

User Action: Fix the EXTERNAL statement so that it has at most one OPTIONAL clause per SUB or FUNCTION.

ILLNESDEF, illegally nested DEFs

Explanation: ERROR - The program contains a DEF function block within another DEF function block.

User Action: Remove the inner DEF block. A DEF cannot contain another DEF.

ILLOPEARG, illegal operation for argument

Explanation: ERROR - The program performs an operation that is inconsistent with the data type of the arguments, for example, an arithmetic operation on variables of the RFA data type.

User Action: Remove the operation or change the data type of the arguments.

ILLOPTBAS, illegal OPTION BASE value

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier contains an OPTION BASE statement that specifies a value other than 0 or 1.

User Action: Change the OPTION BASE statement to specify either 0 or 1.

ILLQUACOM, illegal qualifier combination

Explanation: ERROR - In the BASIC environment, you specified an illegal combination of qualifiers, such as COMPILE/NOSHOW=CDD.

User Action: Issue the command again, using a valid combination of qualifiers.

ILLSTROPE, illegal string operator

Explanation: ERROR - The program specifies an invalid string operation; for example, A$ = B$ – C$.

User Action: Replace the invalid operator.

ILLUSAFIE, illegal usage of FIELDed variable

Explanation: A MAT statement operates on an element of a string array that appears in a FIELD statement.

User Action: Remove the array from the MAT statement.

ILLUSEUNA, illegal use of unary operator

Explanation: ERROR - A compiler directive contains an invalid lexical expression, for example, %IF 1 NOT 2.

User Action: Correct the invalid lexical expression.

ILLWAIVAL, WAIT value must be in the range 0 to 255 inclusive

Explanation: ERROR - An integer expression was specified on a WAIT clause that is less than 0 or greater than 255.

User Action: Specify an integer expression from 0 through 255.

IMMMODOPE, immediate mode operation requires storage allocation

Explanation: ERROR - An immediate mode statement attempted to allocate storage, for example, to create a new variable.

User Action: None. You cannot create new storage in immediate mode.

IMMNOTANS, immediate mode not valid when ANSI

Explanation: ERROR - An immediate mode statement was typed when in ANSI mode.

User Action: None.

IMPCNTNOT, implied continuation not allowed

Explanation: ERROR - The program contains an implied continuation line after a statement that does not allow implicit continuation, for example, a DATA statement.

User Action: Use an ampersand (&) to continue the statement.

IMPDECILL, implicit declaration of <name> illegal in immediate mode

Explanation: ERROR - A new variable was named in an immediate mode statement after a STOP, for example, PRINT B after a STOP in a program that has no variable named B.

User Action: None. You cannot create new variables in immediate mode after a STOP statement.

IMPDECNOT implied declaration not allowed for <name> with /EXPLICIT

Explanation: ERROR - A program compiled with the /TYPE=EXPLICIT qualifier contains an implicitly declared variable.

User Action: Declare the variable explicitly or compile the program without the /TYPE=EXPLICIT qualifier.

INACODFOL, inaccessible code follows line <n> statement <m>

Explanation: WARNING - The program contains one or more statements that cannot be accessed, for example, a multistatement line whose first statement is a GOTO, EXIT, ITERATE, RESUME, or RETURN.

User Action: Make sure that these statements are the only statements on the line, or the last statement on a multistatement line.

INCDIRSYN, INCLUDE directive syntax error

Explanation: ERROR - A %INCLUDE directive either is not followed by a quoted string or incorrectly uses the %FROM %CDD or %FROM %LIBRARY clause.

User Action: Supply either a quoted string or the correct syntax for the %FROM %CDD or %FROM %LIBRARY clause.

INCFUNUSA, inconsistent function usage for function <name>

Explanation: ERROR - The parameter list in a DEF function invocation contains a string where the function expected a number, or vice versa. This message is issued only when the invocation occurs before the DEF statement in the program.

User Action: Supply a correct parameter in the function invocation or correct the parameter list in the DEF.

INCRMSERR, INCLUDE directive RMS error number <number>

Explanation: ERROR - A %INCLUDE directive caused an RMS error when accessing the specified file.

User Action: Take action based on the reported RMS error number.

INCSUBUSE, inconsistent subscript use for <array-name>

Explanation: ERROR - The number of subscripts in an array reference does not match the number of subscripts specified when the array was created.

User Action: Specify the same number of subscripts.

INIOUTRAN, initial value must be within the specified range

Explanation: ERROR - The specified initial value is not within the range specified in the RANGE clause.

User Action: Change either the initial value or the range values so that the initial value falls within the range.

INPPROMUS, input prompt must be a string constant

Explanation: ERROR - An INPUT, LINPUT, or INPUT LINE statement list contains a numeric constant immediately following the statement.

User Action: Remove the numeric constant. You can specify only a string constant immediately after an INPUT, LINPUT, or INPUT LINE statement.

INSERTB, assuming <keyword> before <keyword>

Explanation: ERROR - The program contains a syntax error. VAX BASIC assumes a keyword is missing and continues compilation under that assumption so that other errors may be detected. The actual program line remains unchanged and no object file is produced.

User Action: Examine the line carefully to discover the error. Change the program line to correct the syntax error.

INSERTM, assuming <keyword> to match <keyword>

Explanation: ERROR - The program contains a syntax error. VAX BASIC assumes a keyword is misspelled and continues compilation under that assumption so that other errors may be detected. The actual program line remains unchanged and no object file is produced.

User Action: Examine the line carefully to discover the error. Change the program line to correct the syntax error.

INSSPADYN, insufficient space for MAP DYNAMIC variable in MAP <name>

Explanation: ERROR - A variable named in a MAP DYNAMIC statement is larger than the MAP. For example, an HFLOAT variable in a MAP that is only four bytes long.

User Action: Increase the size of the MAP so that it is large enough to hold the largest member.

INTCODERR, an internal coding error has been detected. Submit an SPR.

Explanation: ERROR - An error has been detected in the VAX BASIC compiler.

User Action: Please submit an SPR with the source code of a small program that produces this error.

INTCONEXC, integer constant exceeds machine integer size

Explanation: ERROR - The value specified in a DECLARE CONSTANT statement exceeds the largest allowable value for an integer. The maximum is 2147483647.

User Action: Supply a value in the valid range.

INTCONREQ, integer constant required

Explanation: ERROR - The program contains a noninteger named constant in a context that requires an integer. For example:

```
DIM A ('123'D)
```

User Action: Supply an integer constant.

INTDATTYP, integer data type not supported in ANSI

Explanation: ERROR - A program compiled with the /ANSI_STANDARD qualifier contains an integer variable or array.

User Action: Remove the integer variable or array.

INTERR, integer error or overflow

Explanation: WARNING - The program contains an integer expression whose value is outside the valid range.

User Action: Modify the expression so that its value is within the allowable range or use an integer data type that can contain all possible values for the expression.

INTERRDES, please submit an SPR—internal error in comment processing

Explanation: WARNING - An error has been detected while processing a comment in the VAX BASIC compiler.

User Action: Please submit an SPR with the source code of a small program that produces the error.

INTERRSCA, please submit an SPR—internal error in SCA support

Explanation: ERROR - An error has been detected in the SCA support in the VAX BASIC compiler. If you recompile your program without the /ANALYSIS_DATA qualifier, this error should no longer appear.

User Action: Please submit an SPR with the source code of a small program that produces the error.

INVCHNNUM, invalid channel number, must be greater than zero

Explanation: ERROR - A channel number less than or equal to zero was specified.

User Action: Change the channel number to be greater than zero.

INVCONREQ, invalid conversion requested

Explanation: ERROR - The program contains a reference to the REAL or INTEGER functions and the argument is an entire array, GROUP, RECORD, or RFA expression.

User Action: Remove the invalid argument. The argument to these functions must be a numeric expression.

INVINTTYP, invalid integer type

Explanation: ERROR - A reference to the INTEGER function contains an invalid data-type keyword. For example, A = INTEGER(A, SINGLE).

User Action: Change the invalid data-type keyword. The INTEGER function returns only BYTE, WORD, or LONG values.

INVLOGNAM, invalid logical name

Explanation: ERROR - The argument to the ASSIGN compiler command specified a logical name length of less than 1 or greater than 63.

User Action: Supply a valid logical name.

INVPRISPE, invalid priority specification, expecting < or >

Explanation: ERROR - On the SET INPUT PRIORITY statement, you specified a character other than < or > to indicate the relative priorities of the two transformation numbers.

User Action: Specify the priority relationship with less than < (lower priority) or greater than > (higher priority).

INVREATYP, invalid real type

Explanation: ERROR - A reference to the REAL function contains an invalid data-type keyword, for example, A = REAL(A, LONG).

User Action: Change the invalid data-type keyword. The REAL function returns only SINGLE, DOUBLE, GFLOAT, or HFLOAT values.

INVSUBTYP, <data-type> is not a subtype of <data-type>

Explanation: ERROR - The program contains an invalid declaration containing contradictory type declarations, for example, DECLARE REAL BYTE.

User Action: Supply a valid declaration. Use only valid integer subtypes for INTEGER and only valid floating-point subtypes for REAL.

IS_NOTDYN, <name> is not a DYNAMIC MAP variable of MAP <name>

Explanation: ERROR - A REMAP statement names a variable that was not named in the MAP DYNAMIC statement for that MAP.

User Action: Remove the variable from the REMAP statement or name the variable in the MAP DYNAMIC statement for that map.

ITEMUSAPP, ITERATE must appear within a loop

Explanation: ERROR - The program contains an ITERATE statement that is not within a FOR-NEXT, WHILE, or UNTIL loop.

User Action: Remove the ITERATE statement, or surround it with a loop.

JMPBADBLO, jump to line number <line number> is into a controlled block

Explanation: ERROR - The program attempts to transfer control to a WHEN block or associated handler.

User Action: Change the program logic so that it does not transfer control to a WHEN block or associated handler.

JMPBADLAB, jump to label: <label> is into a block

Explanation: ERROR - The program attempted to transfer control into a FOR-NEXT, WHILE, UNTIL, IF, or SELECT-CASE block.

User Action: Change the program logic so that it does not transfer control into a block.

JMPBADLIN, jump to line number <number> is into a block

Explanation: INFORMATION - The program transfers control to a line number within a FOR-NEXT, WHILE, UNTIL, IF, or SELECT-CASE block.

User Action: This is an informational message. However, it is bad programming practice to transfer control into a block.

JMPINTDEF, jump into DEF

Explanation: ERROR - The program attempts to transfer control into a DEF block.

User Action: Change the control statement; you cannot transfer control into a DEF block except by invoking the function.

JMPOUTDEF, jump out of DEF

Explanation: ERROR - The program attempts to transfer control out of a DEF block.

User Action: Change the control statement. Use an EXIT DEF, FNEXIT, FNEND, or END DEF statement to transfer control out of a DEF block.

JMPOUTHAN, jump out of HANDLER

Explanation: ERROR - The program attempts to transfer control out of an error handler.

User Action: Change the control statement. Use an EXIT HANDLER, RETRY, or CONTINUE statement to transfer control out of an error handler.

JMPOUTPRO, jump out of program unit

Explanation: ERROR - In a source file containing more than one program module, a statement attempts to transfer control from one module into another.

User Action: Change the statement that attempts to transfer control; you cannot transfer control into a different program module.

JMPUNRLIN, jump to unreferenceable line number <number>

Explanation: ERROR - A RESUME, GOSUB, or GOTO statement attempts to transfer control to a CASE statement.

User Action: Label or number the SELECT statement and transfer control to the beginning of the SELECT-CASE block.

KEYCANNOT, key <name> in MAP <map-name> cannot be a dynamic variable

Explanation: ERROR - A KEY clause in an OPEN statement specifies a variable declared as dynamic in a MAP DYNAMIC statement.

User Action: Specify a static variable in the KEY clause; that is, declare the variable in a MAP statement, not a MAP DYNAMIC statement.

KEYIS_NEE, key is needed for indexed files

Explanation: ERROR - The program attempts to open an indexed file for output, and the PRIMARY KEY clause is missing.

User Action: Supply a PRIMARY KEY clause.

KEYMUSBE, key must be either word, longword, string, decimal, record or group

Explanation: ERROR - A FIND or GET statement on an indexed file contains a key specification that is not a WORD, LONG, STRING, DECIMAL, or an 8-byte RECORD or GROUP expression.

User Action: Change the key specification to be a WORD, LONG, STRING, DECIMAL, or an 8-byte RECORD or GROUP expression.

KEYMUSTBE, key, <vbl-name> in map <map-name> must be either word, longword, string, decimal, record or group

Explanation: ERROR - An OPEN statement contains a key specification that is not an unsubscripted WORD, LONG, STRING, DECIMAL, or an 8-byte RECORD or GROUP variable.

User Action: Change the key specification to be an unsubscripted WORD, LONG, STRING, DECIMAL, or an 8-byte RECORD or GROUP variable.

KEYNOTMAP, KEY <vbl-name> is not an unsubscripted variable in MAP <name>

Explanation: ERROR - An indexed file OPEN statement specifies a KEY variable that does not appear in a MAP statement.

User Action: Place the KEY variable in the MAP referenced by the OPEN statement's MAP clause.

KEYREQMAP, KEY clauses require a MAP clause

Explanation: ERROR - An OPEN statement specifies KEY clauses without specifying a MAP clause.

User Action: Supply a MAP clause to define the position of the keys in the record buffer.

KEYSEGMUS, key segment <name> in map <map-name> must be a string key

Explanation: ERROR - An OPEN statement specifies a segmented key containing a numeric variable. For example:

```
OPEN "INDEX.DAT" AS FILE #1, ORGANIZATION INDEXED,  &
    PRIMARY KEY (A$, B$, C%), MAP ABC
```

User Action: Specify only string variables in segmented keys.

KEYSINC, <keyword> keyword inconsistent with <keyword>

Explanation: ERROR - An OPEN statement contains contradictory record format specifications, for example, both FIXED and VARIABLE.

User Action: Specify only one record format.

KEYTOOLON, KEY <name> in MAP <name> is too long (max is 255)

Explanation: ERROR - A KEY variable is longer than 255 characters.

User Action: Reduce the length of the KEY variable. The maximum key length is 255 characters.

KEYWORINC, keyword inconsistent with <OPEN clause> clause

Explanation: ERROR - An OPEN statement contains an ALLOW, ACCESS, or RECORDTYPE clause whose keyword argument is invalid, for example, ACCESS FORTRAN.

User Action: Change the clause argument to a valid keyword for that clause.

LABNOTDEF, label <label> not defined

Explanation: ERROR - The program tries to transfer control to a nonexistent label.

User Action: Define the label before transferring control to it.

LABNOTLAB, label <name> does not label an active block statement

Explanation: ERROR - An EXIT statement in a loop, IF-THEN-ELSE or SELECT-CASE block specifies a label that does not refer to that block.

User Action: Change the program so that the label actually refers to the block in which the EXIT statement occurs.

LABNOTLOO, label <name> does not label an active loop statement

Explanation: ERROR - In a loop, an EXIT or ITERATE statement specifies a label that does not refer to that loop.

User Action: Change the program so that the label actually refers to the loop in which the EXIT or ITERATE statement occurs.

LANFEADEC, language feature is declining

Explanation: INFORMATION - The program contains a language feature that is not recommended for new program development, for example, the FIELD statement. This error is reported only when the /FLAG:DECLINING qualifier is in effect.

User Action: Use: 1) MAP, MAP DYNAMIC and REMAP statements instead of FIELD, 2) EDIT$ rather than CVT$$, 3) and overlaid MAPs rather than CVTxx functions.

LANFEAINC, language feature incompatible with BASIC-PLUS-2

Explanation: INFORMATION - The program contains syntax that results in different behavior under VAX BASIC and PDP–11 BASIC-PLUS-2, for example, opening a terminal-format file. This error is reported only when the /FLAG:BP2COMPATIBILITY qualifier is in effect.

User Action: None.

LANFEAINH, language feature inhibits optimization

Explanation: INFORMATION - A program compiled with the /NOSETUP qualifier contains a language feature that requires /SETUP, for example, the RESUME statement. The compilation continues with /SETUP in effect.

User Action: None. The program must be compiled with /SETUP in effect for the language feature to work.

LANFEANOT, language feature not available in BASIC-PLUS-2

Explanation: INFORMATION - The program contains a language element that is not supported in BASIC-PLUS-2, for example, RECORD statements. This error is reported only when the /FLAG:BP2COMPATIBILITY qualifier is in effect.

User Action: If the program must run under both VAX BASIC and PDP–11 BASIC-PLUS-2, you must remove the incompatible language feature.

LANFEAOPE, language feature not available in VAX BASIC

Explanation: ERROR - The program contains a PRINT statement with a RECORD clause. VAX BASIC does not support the RECORD clause.

User Action: Remove the RECORD clause.

LEFBOUSPE, left boundary must be less than the right boundary

Explanation: ERROR - In a statement that specifies a viewport or windowsize, you specified a left boundary that is greater than or equal to the corresponding right boundary.

User Action: Correct the left boundary so that it is less than the right boundary.

LENDYNSTR, string length not allowed on dynamic string <name>

Explanation: ERROR - The program contains a dynamic string variable declaration that specifies a string length.

User Action: Length specifications are allowed only for fixed-length strings; remove the length specification from the dynamic string, or allocate the string in a MAP or COMMON.

LENNUMFIL, string length not allowed on numeric FILL

Explanation: ERROR - The program contains a numeric FILL item that specifies a length.

User Action: Remove the length specification from the numeric FILL item.

LETDIRSYN, LET directive syntax error

Explanation: ERROR - A %LET directive contains a syntax error, for example, an invalid lexical identifier.

User Action: Use the correct syntax for the %LET directive.

LETKEYREQ, LET keyword required in ANSI

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier contains an assignment statement that omits the LET keyword.

User Action: Supply a LET keyword.

LEXDIRSYN, lexical directive syntax error

Explanation: ERROR - A syntax error was detected in a lexical directive.

User Action: Correct the syntax of the lexicial directive.

LEXIDEMUS, lexical identifier must be declared before reference

Explanation: ERROR - You reference a lexical identifier before you declare it.

User Action: Declare the lexicial identifier before you reference it.

LINNOTALL, line numbers not allowed, use the EDIT command

Explanation: ERROR - An EDIT command with a line number has been found in a program without line numbers.

User Action: Use the EDIT command without specifying a line number to invoke a text editor.

LINNUMERR, illegal line number

Explanation: ERROR - The program contains a line number that is outside the valid range or is not a valid integer (note that the percent sign (%) suffix is not valid for line numbers).

User Action: Specify only integer line numbers in the range 1 to 32767, inclusive.

LINNUMINC, line number may not appear in INCLUDE directive file

Explanation: ERROR - The file specified in a %INCLUDE compiler directive contains a line number.

User Action: Remove the line number from the file.

LINNUMUND, line number <n> undefined due to conditional compilation

Explanation: ERROR - The program references a line number that does not appear in the object code as a result of the branch taken in a %IF-%THEN-%ELSE-%END-%IF directive.

User Action: Change the %IF-%THEN-%ELSE-%END-%IF directive or remove the line number reference.

LINREQTWO, LINES output requires at least 2 X,Y points

Explanation: ERROR - A LINE graphic output statement specifies less than 2 points.

User Action: Specify a minimum of 2 points in the LINE graphic output statement.

LNPNOTBP2, programs without line numbers are not allowed in BASIC-PLUS-2

Explanation: INFORMATIONAL - BASIC-PLUS-2 does not support programs without line numbers.

User Action: Add a line number to the first line of the program.

LOGOPENON, logical operation on non-integer quantity

Explanation: ERROR - The program contains a logical operation performed on strings or real numbers.

User Action: Change the logical operands to integers.

LOOINDMUS, loop control variable must be a numeric variable

Explanation: ERROR - A FOR statement specifies a string variable as the loop control variable.

User Action: Specify a numeric variable. You can use only numeric variables as loop control variables.

LOOINIMUS, loop initial value must be a numeric expression

Explanation: ERROR - A FOR statement attempts to assign a string expression as the loop control variable's initial value.

User Action: Remove the string expression. You can assign only numeric values as the loop's initial value.

LOOLIMMUS, loop limit must be numeric

Explanation: ERROR - A FOR statement attempts to assign a string expression as the loop control variable's limiting value.

User Action: Remove the string expression. You can assign only numeric values as the loop control variable's limiting value.

LOOWILNEV, loop will never execute

Explanation: WARNING - The program contains a FOR/NEXT loop that is not executable; for example, FOR I% = 1% TO 0%. Compilation continues, but the loop is ignored.

User Action: Change the loop parameters or insert an appropriate STEP clause.

LOWLSSUP, lower bound must be less than upper bound

Explanation: ERROR - The lower bound specified in the array is greater than the upper bound.

User Action: Correct the bounds.

LOWNOTVIR, lower bound not permitted with virtual arrays

Explanation: ERROR - Lower bounds of virtual arrays must be zero.

User Action: Correct the lower bounds to be zero.

LOWNOTZERO, lower bound must be zero

Explanation: ERROR - The lower bound of the array must be zero.

User Action: Correct the lower bound to be zero.

LOWRANVAL, range lower value must be less than upper value

Explanation: ERROR - In the RANGE clause, the first value is greater than the second value.

User Action: Change the range clause so that the first value is less than the second value.

LRSETNOT, <keyword> is not allowed with MID

Explanation: ERROR - The LSET and RSET keywords are not allowed with MID.

User Action: Change the LSET or RSET keyword to LET.

MAPDYNNOT, MAP DYNAMIC <map-name> may not be larger than 32767 bytes

Explanation: ERROR - A MAP DYNAMIC statement references a map that is greater than 32767 bytes in size.

User Action: Reduce the size of the map, as defined in the MAP statement, or MAP statements, to 32767 bytes or less.

MAPDYNREQ, MAP DYNAMIC <name> requires corresponding static MAP

Explanation: ERROR - The program contains a MAP DYNAMIC statement whose MAP name does not appear in a MAP statement.

User Action: Provide a MAP with the same name as the MAP DYNAMIC name.

MAPNOTDEF, MAP <name> used in OPEN not defined

Explanation: ERROR - An OPEN statement's MAP clause references a nonexistent MAP.

User Action: Define the MAP referenced by the MAP clause, or remove the MAP clause.

MAPTOOLAR, MAP too large in OPEN

Explanation: FATAL - The size of the MAP referenced in an OPEN statement is greater than 32767 bytes.

User Action: Reduce the size of the MAP.

MAPVARALI, variable <name> not aligned in multiple references in MAP <name>

Explanation: ERROR - More than one overlaid MAP contains the same variable, but the variable's position differs in the MAPs.

User Action: The same variable can appear in multiple overlaid MAPs, but the variable must occupy the same position in the PSECT; make sure that the variable appears in the same position in the MAPs.

MAPVARREF, MAP variable <name> referenced before declaration

Explanation: INFORMATION - A reference to a MAP variable occurs before the MAP statement.

User Action: Make sure that the MAP statement precedes any references to variables in the MAP.

MATDIMERR, matrix dimension error

Explanation: ERROR - The program either:

- Contains a MAT IDN, MAT TRN, or MAT INV performed on a 1-dimensional array
- Performs a matrix operation that requires identical subscripts in the operand arrays and those arrays have different subscripts

User Action: Dimension the arrays to the proper number of subscripts.

MATLOWBOU, matrix must have lower bound 0 and upper bound 4

Explanation: ERROR - The specified transformation matrix either has a lower bound other than 0 or an upper bound other than 4.

User Action: Declare the matrix such that both dimensions have a lower bound of 0 and an upper bound of 4.

MATMUL2OP, MAT multiply of 2 4X4 matrices required

Explanation: ERROR - You specified the wrong dimensions in a matrix in the MAT multiply statement or a WITH clause on the DRAW statement. A 2-dimensional matrix with lower bounds 0 and upper bounds 4 in both dimensions is required.

User Action: Declare the matrix to be a 2-dimensional matrix with lower bounds 0 and upper bounds 4 in both dimensions.

MATONEOR2, MAT statements require one or two dimensions

Explanation: ERROR - A MAT statement references an array of more than two dimensions.

User Action: Remove the array reference. MAT statements are valid only on arrays of one or two dimensions.

MAXCONCOM, maximum conditional compilation depth exceeded

Explanation: FATAL - Too many nested %IF-%THEN-%ELSE-%END-%IF directives are contained in the program.

User Action: Reduce the number of nested %IF-%THEN-%ELSE-%END-%IF directives. You can nest up to eight such constructs.

MAXDIMEXC, maximum number of dimensions exceeded. Maximum is 32

Explanation: ERROR - An array declaration specifies more than the allowed number of dimensions.

User Action: Reduce the number of dimensions to 32 or less.

MAXKEYSEG, maximum of 8 key segments exceeded

Explanation: ERROR - An OPEN statement specifies a segmented key with more than eight segments.

User Action: Reduce the number of segments in the KEY clause to eight or less.

MAXPAREXC, maximum parameters exceeded for <name>. Maximum is <number>

Explanation: ERROR - The program attempts to declare a DEF with more than eight parameters or a subprogram with more than 255 parameters.

User Action: Reduce the number of parameters; DEFs allow up to eight parameters and subprograms allow up to 255 parameters.

MAXPAREXP, no more than <number> parameter(s) expected for <sub-func-name>

Explanation: ERROR - An external SUB or FUNCTION was called with more parameters than were specified in the EXTERNAL statement, including both OPTIONAL and non-OPTIONAL parameters.

User Action: Reduce the number of parameters in the call.

MERGE, merged <item> and <item>

Explanation: ERROR - The program contains a syntax error. VAX BASIC assumes that there is an incorrect space, for example, PR INT. Compilation continues so that other errors may be detected. The actual program line remains unchanged and no object file is produced.

User Action: Examine the line carefully to discover the error. Change the program line to correct the syntax error.

MINPAREXP, at least <number> parameter(s) expected for <sub-func-name>

Explanation: ERROR - An external SUB or FUNCTION was called with fewer parameters than were specified as non-OPTIONAL parameters in the EXTERNAL statement.

User Action: Increase the number of parameters in the call so that the number of parameters is equal to or greater than the number of non-OPTIONAL parameters.

MISENDIF, missing END IF directive before end of program unit

Explanation: ERROR - A %IF directive crosses a program module boundary.

User Action: Terminate the %IF with a %END %IF before beginning a new source module.

MISENDFOR, missing END <block> for <block> at line <n> statement <m>

Explanation: ERROR - The program contains a SELECT, IF, or DEF without a matching END statement.

User Action: Supply a matching END statement.

MISMATEND, mismatched END, expected <block>

Explanation: ERROR - The program contains an incorrect END statement, for example, an END RECORD statement instead of an END GROUP statement.

User Action: Supply the correct type of END statement.

MISMATFOR, missing NEXT for <item> at line <n> statement <m>

Explanation: ERROR - The program contains a FOR, WHILE, or UNTIL without a matching NEXT.

User Action: Supply the matching NEXT statement.

MODNOTFND, module <mod-name> not found in text library <text-lib-name>

Explanation: ERROR - The module name you specified in an %INCLUDE directive was not found in the text library you specified.

User Action: Place the module name in the specified text library.

MULCHRARR, multiple character array name not ANSI

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier contains an array whose name contains more than one character.

User Action: Reduce the length of the name to a single character.

MULCHRDEF, multiple character DEF name not ANSI

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier contains a DEF whose name contains more than one character.

User Action: Reduce the length of the name to a single character.

MULDEFLEX, multiple definition of lexical identifier is illegal

Explanation: ERROR - A lexical constant is named in more than one %LET directive.

User Action: Declare the lexical constant only once with %LET.

MULHANSPE, multiple handlers specified for WHEN block

Explanation: ERROR - A WHEN block specifies both an attached and detached error handler.

User Action: Change the WHEN block to specify either an attached or detached error handler.

MULMAIPROG, multiple main program units are illegal

Explanation: ERROR - More than one main program unit has been detected in a single source file.

User Action: Modify your source file so that all VAX BASIC statements are contained within a single main program or within a subprogram.

MULNOTBP2, multiple program units per module not BASIC-PLUS-2 compatible

Explanation: INFORMATION - A program compiled with the /FLAG:BP2COMPATIBILITY qualifier contains more than one program unit. BASIC-PLUS-2 does not allow more than one program unit in a single file.

User Action: Separate the program into individual program units and compile the units separately.

MULOPTBAS, multiple OPTION BASE statements not ANSI

Explanation: ERROR - A program compiled with the /ANSI_STANDARD qualifier contains more than one OPTION BASE statement.

User Action: Specify the OPTION BASE statement only once per program.

MULPRONOT, multiple program units per module not ANSI

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier contains more than one program unit.

User Action: Rewrite the program converting the subprograms to subroutines.

MULSTAPER, multiple statements per line not ANSI

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier contains more than one statement on a line.

User Action: Change the program so that each statement has its own line number.

MULTDEF, multiple definition of <name>

Explanation: WARNING - A variable is declared in more than one declarative statement.

User Action: Make sure that the variable is declared only once.

NAMNOTREC, name <name> is not of a RECORD component

Explanation: ERROR - A RECORD component reference uses an invalid record name, for example, A::B when A is not a RECORD name.

User Action: Change the erroneous reference.

NAMTOOLON, name is too long, changed to <name>

Explanation: WARNING - A variable or array name is longer than 31 characters. VAX BASIC truncates the name to 31 characters and continues compilation so that other errors may be detected. The actual program line remains unchanged and no object file is produced.

User Action: Reduce the length of the variable name to 31 or fewer characters.

NEGFILSTR, negative FILL or string length

Explanation: ERROR - The program contains a negative FILL specification or string length.

User Action: Change the FILL specification or string length to a positive number.

NESFORLOO, nested FOR loops with same control variable <name>

Explanation: ERROR - The program contains nested FOR/NEXT loops that use the same index variable.

User Action: Change the index variable for all but one of the loops.

NOBASFRAM, no BASIC frame on stack

Explanation: ERROR - VAX BASIC could not find a valid stack frame. This could be caused by running a program with /CHECK=NOBOUNDS or by a non-BASIC subprogram.

User Action: Debug the program before running with /CHECK=NOBOUNDS or check the logic of the non-BASIC subprogram.

NODESCALL, no descriptor allocated for array <name>

Explanation: ERROR - An immediate mode statement required an array descriptor, but it was not available. VAX BASIC allocates array descriptors only if the program code requires it.

User Action: None.

NODIAGFILE, unsaved changes, no diagnostics file produced

Explanation: WARNING - The program in memory contains changes that have not been saved. Therefore, no diagnostics file will be produced from this compilation.

User Action: SAVE or REPLACE the file.

NOEDIT, no change made

Explanation: WARNING - The search string in an EDIT command was not located in the text.

User Action: Enter valid search string.

NOFILEALL, a file specification is not allowed with the REPLACE command

Explanation: ERROR - The REPLACE command does not allow the use of a file specification.

User Action: Use either the SAVE command with a file specification or the REPLACE command without one.

NOFRAME, compiled procedure is currently not active

Explanation: WARNING - A program containing multiple compilation units has been stopped while running in the environment due to a STOP statement or a CTRL/C entered by the user. The NOFRAME error indicates that the routine executing when the program stopped is not the last compilation unit in the source file. You can examine or modify a variable in

immediate mode only if the current routine is the last compilation unit in the source file.

User Action: If you do not intend to debug your program in immediate mode, no action is required. If you do intend to debug your program in immediate mode, make the routine which you want to debug the last compilation unit in the source file. The symbols for the last compilation unit are always available. Alternatively, use the VMS Debugger to debug your program.

NOHANSPE, no handler specified for WHEN block

Explanation: ERROR - A WHEN block has been found that does not specify an error handler.

User Action: Specify an error handler for the WHEN block.

NOLINENUM, missing line number on first line

Explanation: WARNING - There is no line number on the first line of the program.

User Action: Add a line number to the first line of the program or remove all line numbers from the program.

NOLNROOM, out of memory for line numbers

Explanation: ERROR - The program contains more line-numbered statements than VAX BASIC allows.

User Action: Change the program so that it uses multistatement lines instead of having each statement on its own line or split the program into one or more program units in separate files.

NOMAPNAME, MAP statement requires map name

Explanation: ERROR - A MAP statement does not specify a map name.

User Action: Specify a name for the MAP.

NOSCAFILE, unsaved changes, no analysis file produced

Explanation: WARNING - The program in memory contains changes that have not been saved. Therefore, no data analysis file will be produced from this compilation.

User Action: SAVE or REPLACE the file.

NOSRCLINE, unsaved changes, no source line debugging available

Explanation: WARNING - The program in memory contains changes that have not been saved. Therefore, no source line debugging will be available from this compilation.

User Action: SAVE or REPLACE the file.

NOSUCHMAP, no such MAP area <name>

Explanation: ERROR - A REMAP statement names a nonexistent MAP area.

User Action: Supply a MAP before executing the REMAP statement.

NOTIMP, not implemented in this version

Explanation: ERROR - The program attempted to use a feature that does not exist in this version of VAX BASIC.

User Action: Examine your program and remove the non-implemented feature.

NOTPASSBY, <item> may not be passed BY <mechanism>

Explanation: ERROR - The program specifies an incorrect passing mechanism for a parameter's data type, or an invalid parameter. For example, you cannot pass an entire array BY VALUE, nor can you pass a label as a parameter.

User Action: Specify a valid parameter or passing mechanism.

NOTRANS, no main program

Explanation: WARNING - When a RUN command was typed, only subroutines or functions were available. VAX BASIC requires a main program to receive the transfer of control.

User Action: Supply a main program.

NOTRECVBY, <item> may not be received by <mechanism>

Explanation: ERROR - A subprogram specifies an invalid parameter or an incorrect passing mechanism for a parameter's data type. For example, you cannot receive an entire array BY VALUE.

User Action: Specify a valid parameter or passing mechanism.

NOTXTROOM, out of memory for statement text

Explanation: ERROR - The program contains more text than VAX BASIC allows.

User Action: Split the program into one or more program units.

NOVALUE, <text> keyword requires a value

Explanation: ERROR - A keyword command was typed without a value.

User Action: Supply a valid keyword value.

NUMARREXP, numeric array expected

Explanation: ERROR - A CHANGE statement does not specify a numeric array.

User Action: Supply a numeric array in the CHANGE statement.

NUMCONREQ, numeric constant required

Explanation: ERROR - The program contains a string in a context that requires a numeric constant. For example:

```
DECLARE INTEGER CONTANT A = "ABC"
```

User Action: Supply a numeric constant.

NUMIS_NEE, numeric expression is required

Explanation: ERROR - The program contains a string expression in a context that requires a numeric expression, for example, WHILE A$.

User Action: Supply a numeric expression.

NUMVARREQ, numeric variable required

Explanation: ERROR - A nonnumeric variable was found with a numeric data type.

User Action: Specify a numeric variable.

OBJFAIL, failure in loading object file

Explanation: FATAL - Either an attempt was made to load a non-BASIC object module, or the compiler could not find the object file referenced by a CALL statement or EXTERNAL FUNCTION reference.

User Action: If the object file resides in the VAX Common Run-Time Library, you must link the program at DCL level. If the object file is in a user-supplied library, use the LIBRARY command to install the missing object module. You can load only VAX BASIC object modules.

ONENOTWHE, ON ERROR not allowed in WHEN block or handler

Explanation: ERROR - An ON ERROR statement has been found in a WHEN block or an associated error handler.

User Action: Remove the ON ERROR statement from the WHEN block or associated error handler.

OPEEXPNOT, operator expected, not found

Explanation: ERROR - A compiler directive contains an invalid lexical expression that has a right parenthesis immediately followed by a lexical identifier.

User Action: Correct the lexical expression.

OPEMUSFOL, operator must follow right parenthesis

Explanation: ERROR - The program contains an incorrect lexical expression.

User Action: Correct the lexical expression.

OPENIN, error opening <file-name> as input

Explanation: ERROR - An error was detected in attempting to open a file for input.

User Action: Make sure the file specification is correct.

OPENOUT, error opening <file-name> as output

Explanation: ERROR - An error was detected in attempting to open a file for output.

User Action: Supply a valid file specification, or take corrective action based on the associated message.

OPNCLAVAL, OPEN clause <clause> value greater than <number>

Explanation: ERROR - An OPEN statement contains a RECORDSIZE, FILESIZE, EXTENDSIZE, WINDOWSIZE, BLOCKSIZE, BUCKETSIZE, or BUFFER clause whose argument is too large.

User Action: Supply a smaller value for the argument.

OPNDUPCLA, duplicate OPEN clause

Explanation: WARNING - An OPEN statement contains more than one clause of the same type.

User Action: Remove one of the clauses.

OPNILLCLA, <clause> is an unsupported OPEN clause

Explanation: ERROR - An OPEN statement specifies invalid attributes for the file, for example, CLUSTERSIZE on VMS systems, or uses the keyword COMMON in an I/O clause.

User Action: Substitute valid attributes for the file or remove the COMMON keyword.

OPNINCCLA, <keyword> keyword is inconsistent with file organization

Explanation: ERROR - An OPEN statement contains a clause that is not appropriate for the specified file organization, for example, opening a relative file with the ACCESS APPEND clause.

User Action: Remove the inconsistent clause.

OPTBASMUS, OPTION BASE must be before array declarations

Explanation: ERROR - A program compiled with the /ANSI_STANDARD qualifier contains an OPTION BASE statement that lexically follows an array declaration.

User Action: Move the OPTION BASE statement so that it lexically precedes the array declaration.

OPTCLACON, OPTION clause contradicts prior clause

Explanation: ERROR - The OPTION statement contains contradictory clauses, for example, specifying the default integer size as both BYTE and LONG.

User Action: Remove one of the clauses.

OPTNOTALL, OPTIONAL not allowed on EXTERNAL PICTURE

Explanation: ERROR - An attempt was made to specify the OPTIONAL keyword on an EXTERNAL PICTURE declaration. This is not allowed because OPTIONAL parameters should be used for calling non-BASIC procedures only.

User Action: Remove the OPTIONAL keyword from the EXTERNAL PICTURE declaration.

OPTOUTSEQ, OPTION statement out of sequence

Explanation: ERROR - The OPTION statement is either: 1) not the first statement in a main program, or 2) not the first statement following the SUB or FUNCTION statement.

User Action: Move the OPTION statement so that it is either the first statement in the main program or the first statement following the SUB or FUNCTION statement in the subprogram.

ORGUNDREQ, ORGANIZATION UNDEFINED requires FOR INPUT clause

Explanation: ERROR - The program opens a file with ORGANIZATION UNDEFINED, but does not specify FOR INPUT.

User Action: Specify FOR INPUT in the OPEN statement. You cannot create a file with an undefined file organization.

OVFCHKSUP, OVERFLOW checking supported only for INTEGER and DECIMAL

Explanation: ERROR - Overflow checking was specified for a floating-point data type in: 1) a compiler command, 2) a qualifier to the DCL BASIC command, or 3) an OPTION statement.

User Action: Specify overflow checking only for INTEGER or DECIMAL data types or both.

OVRNOLINE, <keyword> overrides NOLINE

Explanation: WARNING - The program: 1) was compiled with /NOLINES and 2) uses a keyword that requires line number information. For example, ERL and RESUME with a line number both require that the program be compiled with /LINES.

User Action: None. If you use a keyword that requires line number information, VAX BASIC automatically overrides the /NOLINE qualifier.

PAREXPFOR, <n> parameters expected for <routine>

Explanation: ERROR - The CALL or invocation of a routine specifies a different number of parameters than the number specified when the routine was declared.

User Action: Change the number of parameters to match the number declared.

PARINCPRE, parameter <name> inconsistent with previous declaration or reference

Explanation: ERROR - An external subprogram or DEF function declaration specifies a data type for one of the parameters that is different than the data type the SUB, FUNCTION, or DEF statement specifies.

User Action: Change the specified data type in either the declaration or the SUB, FUNCTION, or DEF statement so that the data types agree.

PARMODCHA, mode for parameter <n> of routine <name> changed to match declaration

Explanation: INFORMATION - The data type specified in a routine invocation does not match that of the routine declaration. VAX BASIC issues this message only if the data-type conversion results in a parameter that cannot be modified by the routine that was invoked.

User Action: Make the data-type specifications in the declaration and the invocation match.

PARMODNOT, mode for parameter <n> of routine <name> not as declared

Explanation: ERROR - The CALL or invocation of a routine specifies a string argument for a parameter that was specified as a numeric when the routine was declared, or vice versa.

User Action: Change the string parameter to numeric, or vice versa.

PARNOTENT, parenthesis illegal, entire array required context

Explanation: ERROR - Parenthesis are used to specify an entire array in a context where an entire array is always required.

User Action: Remove the empty parenthesis from the entire array reference.

PARSTRNOT, parameter <n> of <type> structure not as declared

Explanation: ERROR - The actual parameter list in subprogram CALL or an invocation specifies an entire array where the subprogram declaration specified a simple variable or vice versa.

User Action: Change the actual parameter list to match the declared parameter list or vice versa.

PARTYPREQ, parameter type specification required with /EXPLICIT

Explanation: ERROR - In a program compiled with /TYPE=EXPLICIT, no data-type keyword is specified for a parameter.

User Action: Supply a data-type keyword for the parameter. There are no default data types when you compile a program with /TYPE=EXPLICIT.

PASMECDEF, passing mechanism not allowed for DEF

Explanation: ERROR - A DEF function declaration specifies a passing mechanism for a parameter.

User Action: Remove the passing mechanism clause.

PASMECDIS, passing mechanism disagrees with declaration

Explanation: ERROR - The CALL or invocation of a routine specifies a different passing mechanism for a parameter than that specified when the routine was declared.

User Action: Remove the BY clause specified in the CALL or invocation; VAX BASIC automatically passes parameters with the passing mechanism specified when the routine was declared.

PASMECNOT, passing mechanism not allowed for <item>

Explanation: ERROR - A program specifies a passing mechanism in a context other than the invocation or declaration of an external subprogram.

User Action: Remove the passing mechanism clause.

PASWITNO, <name> has a passing mechanism specified with no parameter list

Explanation: WARNING - A CALL statement, external function reference, or EXTERNAL statement specifies a BY clause but does not specify a formal parameter list.

User Action: Remove the BY clause or supply a parameter list.

PATNOTREC, path name does not specify a CDD/Plus record

Explanation: ERROR - The %INCLUDE directive contains an invalid path name for a record definition.

User Action: Supply a valid path name for a record definition.

PICWHINOT, exit from PICTURE while not in PICTURE

Explanation: ERROR - An EXIT PICTURE statement was found in a module that is not a PICTURE subprogram.

User Action: Remove the EXIT PICTURE statement.

PLACENODESIGN, placeholders illegal without /DESIGN=PLACEHOLDERS

Explanation: ERROR - A placeholder occurred in the source file and the /DESIGN=PLACEHOLDERS option was not specified.

User Action: Recompile the program and specify the qualifier.

PLACENODOT, repetition of pseudocode placeholders not allowed

Explanation: ERROR - A pseudocode placeholder was syntactically incorrect.

User Action: You should remove the trailing periods following the pseudocode placeholder.

PLACENOEXE, placeholders detected - source cannot be executed

Explanation: ERROR - The source code for a RUN command in immediate mode contained at least one placeholder, therefore it could not be executed.

User Action: You should remove the placeholders from the source code and reissue the command.

PLACENOOBJ, placeholders detected - no object produced

Explanation: INFORMATION - The program contained one or more placeholders and therefore no object module was created.

User Action: Remove the placeholders from the source code.

PLACEUNMAT, unmatched placeholder delimiter

Explanation: ERROR- A placeholder was syntactically incorrect because the number of opening and closing brackets did not match.

User Action: First, make sure that the placeholder does not span multiple source lines. Second, add or remove brackets until they are appropriately paired.

PLACEWRDOT, invalid placeholder repetition

Explanation: ERROR - A list placeholder was syntactically incorrect. Three periods were expected.

User Action: Add trailing periods until there are three periods following the placeholder.

POIREQONE, POINTS output requires at least 1 X,Y point

Explanation: ERROR - You do not specify a point in the POINT graphic output statement.

User Action: Specify a minimum of 1 point in the POINT graphic output statement.

POSGTRTAR, starting position greater than target length

Explanation: ERROR - The starting value in the MID statement is greater than the length of the string.

User Action: Correct the value to be less than or equal to the length of the string.

PRELOGNAM, previous logical name assignment replaced

Explanation: INFORMATION - The specified logical name already existed. The new equivalence name replaces the old one.

User Action: None.

PRICDDERR, prior severe CDD/Plus error

Explanation: ERROR - There have been one or more severe CDD/Plus errors, and this may be the reason for the following errors.

User Action: Recompile the program after correcting the first CDD/Plus-related errors.

PRIUSICLA, PRINT USING clause must be a string expression

Explanation: ERROR - A PRINT USING statement specifies a numeric format string.

User Action: Supply a valid format string.

PRIUSICON, PRINT USING conflicts with RECORD clause

Explanation: ERROR - A PRINT USING statement contains a RECORD clause.

User Action: Remove the RECORD clause or use the PRINT statement instead of PRINT USING.

PROSTRNES, program structures nested too deeply

Explanation: FATAL - The program contains too many nested block constructs, for example, DEF function definitions.

User Action: Reduce the number of nested block constructs.

PROTOOBIG, program too big to compile

Explanation: FATAL - The program is too big.

User Action: Recode the program as two or more modules.

PROWHINOT, exit from PROGRAM while not in a main program

Explanation: ERROR - An EXIT PROGRAM statement was found in a program unit that is not a main program.

User Action: Use the type of EXIT appropriate to the program unit.

QUALERR, unknown qualifier <name>

Explanation: ERROR - An attempt was made to enter an invalid qualifier to a SET, LOCK, or COMPILE command.

User Action: Enter the SET, LOCK, or COMPILE command with the correct qualifier.

RADNOTSUP, radix not supported

Explanation: ERROR - A literal constant specifies a radix. For example, in the following DECLARE statement, H is an invalid radix specifier:

```
10      DECLARE LONG CONSTANT A = H"111"
```

User Action: Specify a valid radix. See the *VAX BASIC Reference Manual* for a list of the radices VAX BASIC allows.

REAACCINC, READ access inconsistent with FOR OUTPUT

Explanation: ERROR - An OPEN statement specifies FOR OUTPUT and ACCESS READ.

User Action: FOR OUTPUT specifies that a new file is created; ACCESS READ specifies that the program can only read the file. If you want to create a new file, remove the ACCESS READ clause; if you want read-only access to a file, specify FOR INPUT.

READERR, error reading <file-name>

Explanation: ERROR - An error was detected in attempting to read a file.

User Action: Supply a valid file specification or take corrective action based on the associated message.

REAWITDAT, READ without DATA statement

Explanation: ERROR - The program contains a READ statement and there are no DATA statements.

User Action: Supply a DATA statement or remove the READ statement.

RECENTARR, RECORD entire array must not have subfields specified

Explanation: ERROR - A RECORD component reference specifies an array before the end of the component path, for example, A::B(,)::C.

User Action: Remove the erroneous reference.

RECFILTOO, <field-name> from CDD/Plus has FILL too large

Explanation: ERROR - The total size of a CDD/Plus record is greater than 65535 bytes.

User Action: Reduce the size of the record.

RECKEYQAD, entire RECORD or GROUP must be 8 bytes in length

Explanation: ERROR - The user attempts to specify an entire RECORD or GROUP name in a key value field on a GET or FIND statement and the size of the structure does not match the size of the QUADWORD.

User Action: When specifying a quadword key, use an 8-byte RECORD or GROUP. Otherwise, specify the name of an elementary item in the RECORD or GROUP.

RECNOTBY, record may not be passed BY <mechanism>

Explanation: ERROR - The program attempts to pass a record to a subprogram using either the BY VALUE or BY DESC parameter-passing mechanism.

User Action: Remove the passing mechanism, or specify BY REF. VAX BASIC programs can pass records only by reference.

RECNOTDEF, record type <name> not defined

Explanation: ERROR - The program declares an instance of a user data type, but this type was not defined in the program module.

User Action: Define the data type with a RECORD statement.

RECOVEMAP, RECORDSIZE overflows MAP

Explanation: ERROR - An OPEN statement contains both a RECORDSIZE clause and a MAP clause, and the RECORDSIZE clause is larger than the MAP.

User Action: Make the RECORDSIZE the same as the MAP size.

RECRECDEF, recursive RECORD definition of type <name>

Explanation: ERROR - The program contains two or more RECORD statements that reference each other.

User Action: Change the program so that the RECORD statements do not point at each other.

RECTOBIGL, record too big from module <mod-name> in text library <text-lib-name>

Explanation: ERROR - the text library module specified in an %INCLUDE directive contains a record longer than 255 bytes.

User Action: Extract the module from the text library, edit it to remove any records longer than 255 bytes, and replace the module in the text library.

RECTOOBIG, record too big from INCLUDE directive file

Explanation: ERROR - The file specified in an %INCLUDE directive contains a record longer than 255 bytes.

User Action: Edit the file to remove any records longer than 255 bytes.

RECTOOLAR, RECORD too large. Limit is 65535 bytes.

Explanation: ERROR - The components of a RECORD definition add up to more than 65535 bytes, or 32767 bytes if the RECORD is used as an array component.

User Action: Reduce the size of the RECORD definition.

REMARRREF, entire REMAPPED array <name> cannot be passed BY REF

Explanation: ERROR - The program attempts to pass an array declared in a MAP DYNAMIC statement to an external subprogram by reference.

User Action: Entire remapped arrays must be passed by descriptor. Specify the BY DESC passing mechanism either in the EXTERNAL declaration or the subprogram invocation.

REMNOTALL, REM statement not allowed in programs without line numbers

Explanation: ERROR - A REM statement has been found in a program without line numbers.

User Action: Remove the REM statement.

REPLACE, assuming <operator(s)> replaced by <operator>

Explanation: ERROR - The program contains a syntax error. VAX BASIC found incorrect or multiple operators where another single operator makes more sense, for example, 10 A = = B. Compilation continues so that other errors may be detected. The actual program line remains unchanged and no object file is produced.

User Action: Examine the line carefully to discover the error. Change the program line to correct the syntax error.

REQNUMEXP, <item> requires a numeric expression

Explanation: ERROR - The program contains a string expression in a context requiring a numeric expression.

User Action: Supply a numeric expression.

REQSTREXP, <item> requires string expression

Explanation: ERROR - The program contains a numeric expression in a context requiring a string expression, for example, the file specification in an OPEN statement or the default file specification in a DEFAULTNAME clause.

User Action: Supply a string expression.

RESABOCON, RESEQUENCE aborted due to conditional compilation

Explanation: ERROR - A resequenced program contains a %IF-%THEN-%ELSE-%END-%IF directive.

User Action: Remove the %IF-%THEN-%ELSE-%END-%IF directive.

RESABOSYN, RESEQUENCE aborted due to syntax error

Explanation: ERROR - A RESEQUENCE operation was terminated because the program was not syntactically correct.

User Action: Correct the syntax error and retry the RESEQUENCE operation.

RESATTINC, result attributes inconsistent with prior declaration

Explanation: ERROR - An external or DEF function declaration specifies a data type for the function's result, which is different from the data type the DEF or FUNCTION statement specifies.

User Action: Change the specified data type in either the declaration or the DEF or FUNCTION statement so that the data types agree.

RESINCLIN, RESEQUENCE cannot be used if INCLUDE files reference line numbers

Explanation: ERROR - The current program references an include file that contains line number references, for example, GOTO.

User Action: Remove the %INCLUDE directive. VAX BASIC cannot resequence lines in an INCLUDE file.

RESLINGTR, RESEQUENCE cannot generate line numbers greater than 32767

Explanation: ERROR - The RESEQUENCE command specified an interval or starting point that would have created a line number greater than 32767.

User Action: Reduce the interval or the starting point.

RESNOTWHE, RESUME not allowed in WHEN block or handler

Explanation: ERROR - A RESUME statement has been found in a WHEN block or an associated error handler.

User Action: Remove the RESUME statement from the WHEN block or associated error handler.

RESORDLIN, RESEQUENCE cannot change the order of or delete lines

Explanation: ERROR - The RESEQUENCE command specifies invalid source program changes.

User Action: Supply a valid RESEQUENCE command.

RETCONMUS, RETRY and CONTINUE must appear in error handlers

Explanation: ERROR - A RETRY or CONTINUE statement is not in an error handler associated with a WHEN block protected region.

User Action: Remove the RETRY or CONTINUE statement.

RFAEXPREQ, RFA expression required

Explanation: ERROR - A GET BY RFA statement contains an expression that is not of the RFA data type.

User Action: Supply a valid RFA expression.

RFANOTALL, RFA not allowed in this context

Explanation: ERROR - The program attempts to use an RFA expression in an arithmetic expression or other invalid context.

User Action: Remove the RFA expression. You can use the RFA data type only in file I/O, in an assignment statement, or in a comparison.

ROUSUPDEC, ROUNDing supported only for DECIMAL

Explanation: ERROR - Rounding was specified for a non-DECIMAL data type in: 1) a compiler command, 2) a qualifier to the BASIC DCL command, or 3) an OPTION statement.

User Action: Specify rounding only for the DECIMAL data type.

RPTCOUMUS, repeat count must be positive numeric

Explanation: ERROR - A FILL item specifies a nonnumeric or negative repeat count, for example, FILL(A$) or FILL(–3).

User Action: Supply a valid repeat count.

SCAFACINH, SCALE factor inhibits optimization

Explanation: INFORMATION - This error is reported only when the /SETUP qualifier is in effect. Specifying a scale factor prevents optimization of the compiler-generated code.

User Action: Compile the program without specifying a scale factor.

SCAFILMUS, ANALYSIS file must be random access - no ANA file produced

Explanation: WARNING - The file specification on the /ANALYSIS_DATA qualifier specifies a nonrandom access device; therefore, no analysis data file will be produced. VAX BASIC ignores the /ANALYSIS_DATA qualifier and continues compilation.

User Action: Specify a random access device on the file specification on the /ANALYSIS_DATA qualifier.

SCALE0, scale factor used is 0 for single precision

Explanation: WARNING - An attempt was made to set the SCALE factor while in single precision.

User Action: Set the precision to /DOUBLE. You cannot use scaling when in single precision.

SCANOTANS, /ANALYSIS_DATA qualifier not allowed with /ANSI

Explanation: ERROR - The /ANALYSIS_DATA qualifier conflicts with the /ANSI_STANDARD qualifier.

User Action: Specify either the /ANALYSIS_DATA qualifier or the /ANSI_STANDARD qualifier, but not both.

SCAOUTRAN, SCALE is out of range. Valid is 0 to 6.

Explanation: ERROR - The OPTION statement specifies a scale factor that is not between zero and six, inclusive.

User Action: Supply a valid scale factor.

SEQERR, attempt to sequence over existing statement

Explanation: ERROR - A SEQUENCE command specifies a starting line number that already exists in the VAX BASIC source program in memory.

User Action: Specify a starting line number higher than any existing line or delete the old statement before using the SEQUENCE command.

SEVERRSCA, please submit an SPR—internal error in SCA support

Explanation: FATAL - A severe error has been detected in the SCA support in the VAX BASIC compiler. If you recompile your program without the /ANALYSIS_DATA qualifier, this error should no longer occur.

User Action: Please submit an SPR with the source code of a small program that produces the error.

SEVINTERR, severe internal error has been detected. Submit an SPR.

Explanation: FATAL - An error has been detected in the VAX BASIC compiler.

User Action: Please submit an SPR with the source code of a small program that produces this error.

SHRNOTAVL, Unable to access the shareable image <name>

Explanation: ERROR - The shareable image is not available on your system.

User Action: Install the correct version of the required shareable image.

SPANOSPA, SPAN is inconsistent with NOSPAN

Explanation: WARNING - An OPEN statement specifies both SPAN and NOSPAN.

User Action: Remove one of the clauses.

SPELL, assuming <item> intended to be the keyword: <keyword>

Explanation: ERROR - The program contains a syntax error. VAX BASIC assumes that a keyword has been misspelled, and compilation continues so that other errors may be detected. The actual program line remains unchanged and no object file is produced.

User Action: Examine the line carefully to discover the error. Change the program line to correct the syntax error.

SPENUMEXC, specified numeric exceeds valid character code

Explanation: ERROR - A quoted literal of type character (C) contains a value outside the valid range, for example, '300'C.

User Action: Use a valid ASCII value.

STACKOVF, stack frame overflow for variables

Explanation: ERROR - The program requires too much space for dynamic variables.

User Action: Reduce the number of dynamic variables or place some of the variables in a MAP or COMMON.

STANOTALL, statement not allowed within a PICTURE definition

Explanation: ERROR - The statement you specified is not allowed in a PICTURE definition.

User Action: Remove the statement from the PICTURE definition.

STARISNEE, star (*) is needed in DEF, not "/"

Explanation: ERROR - The program contains a statement that starts with DEF/.

User Action: Change the DEF/ to DEF*.

STRARRNOT, string array not ANSI

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier contains a string array.

User Action: Remove the string array.

STRCONEXP, string constant expression is too long

Explanation: ERROR - The program contains a DECLARE STRING CONSTANT statement where the value assigned to the constant exceeds the maximum number of characters allowed for string constant expressions. The maximum length of a string constant expression at compile-time is 498 characters.

User Action: Change the string constant to a string variable and assign the string expression to the variable at run time.

STRCONREQ, string constant required

Explanation: ERROR - The program contains a numeric expression in a context that requires a string expression, for example:

```
DECLARE STRING CONSTANT ABC = 123
```

User Action: Supply a string literal or a named string constant.

STRDEFNOT, string DEF not ANSI

Explanation: INFORMATION - A program compiled with the /ANSI_STANDARD qualifier contains a string DEF.

User Action: Remove the string DEF.

STRLENANY, string length not allowed on ANY

Explanation: ERROR - An ANY parameter specifies a string length in an EXTERNAL statement. This is not allowed because ANY implies that you can use any data type, not specifically a string data type.

User Action: Remove the string length specification from the ANY clause.

STRIS_NEE, string expression is required

Explanation: ERROR - The program contains a numeric expression where a string expression is needed, for example, NAME 1% AS "ABC.DAT".

User Action: Supply a string expression.

STRLENDYN, string length not allowed on MAP DYNAMIC variable

Explanation: ERROR - A string variable in a MAP DYNAMIC statement specifies a string length.

User Action: Remove the string length. All string variables named in a MAP DYNAMIC statement have a length of zero until a REMAP statement executes.

STRLENINC, virtual array string <name> length increased from <n> to <m>

Explanation: WARNING - In a string virtual array DIM statement, the specified string length is not a power of two.

User Action: None. VAX BASIC increases the string length to the next higher power of two.

STRLENMUS, string length specification for <name> must be numeric

Explanation: ERROR - The length specification for a fixed-length string is nonnumeric, for example, COMMON A$ = "ABC".

User Action: Supply a numeric length specification.

STRLENNOT, string length not allowed on numeric variable <name>

Explanation: ERROR - The declaration for a numeric variable contains a string length specification.

User Action: Remove the string length specification.

STRLENTRU, virtual array string <name> length truncated from <n> to <m>

Explanation: WARNING - A string virtual array specifies a string length greater than 512. VAX BASIC truncates the length specification to 512.

User Action: None. The maximum string length for virtual arrays is 512.

STRLITREQ, string literal required for compiler directive

Explanation: ERROR - A quoted string is missing in a compiler directive that requires one, for example, %IDENT.

User Action: Supply a string literal for the compiler directive.

STROUTRAN, string is too large

Explanation: ERROR - A string exceeds the maximum allowable length. The maximum length is 65535 characters.

User Action: Reduce the length of the string.

STRRECFIE, string record element may not be FIELDed

Explanation: ERROR - A FIELD statement contains a string record element as the fielded variable.

User Action: Replace the string record element with a dynamic string. Fielded variables must be dynamic.

STRRECFOR, stream format must have sequential organization

Explanation: ERROR - A file was opened using STREAM as a record format, but the specified organization was not SEQUENTIAL.

User Action: Change the OPEN statement so that it specifies ORGANIZATION SEQUENTIAL.

STRVAREXP, string variable expected

Explanation: ERROR - A CHANGE statement specifies a numeric variable.

User Action: Supply a string variable; the CHANGE statement changes a string variable to a numeric array and vice versa.

STRVARREQ, string variable required

Explanation: ERROR - A statement references a numeric variable instead of a string variable, for example, LINPUT A%.

User Action: Supply a string variable instead of a numeric variable.

SUBMAYNOT, subscript may not be specified for entire array

Explanation: ERROR - A CALL statement or external function reference passes an entire array as a parameter and contains a subscript expression, for example, A(,,3).

User Action: Remove the subscript expression. You cannot specify any subscripts when passing an entire array as a parameter.

SUBOUTRAN, subscript out of range for <array-name>

Explanation: ERROR - The program references an array element with constant subscript(s) outside the bounds of the array.

User Action: Check program logic to make sure all subscripts are within the bounds of the array.

SUBRECCOM, subscripting error in RECORD component

Explanation: ERROR - The program contains a RECORD component reference with invalid subscripts, for example, A::B(1,2)::C where B has only one subscript, or A::B where A requires a subscript.

User Action: Change the erroneous reference. You must specify as many subscripts as were defined in the RECORD.

SUBWHINOT, exit from SUB seen while not in SUB

Explanation: ERROR - A program contains an EXIT SUB or SUBEXIT statement with no preceding SUB statement.

User Action: If the program is a subprogram, supply a SUB statement; otherwise, remove the EXIT SUB or SUBEXIT statement.

SUFFILNOT, suffix not allowed on FILL after datatype keyword

Explanation: ERROR - A FILL item defined with an explicit data type ends in a percent or dollar sign.

User Action: Remove the FILL item's percent or dollar sign.

SUFINTONLY, % only allowed with BYTE, WORD, LONG, or INTEGER keywords

Explanation: ERROR - The % suffix is only allowed on integer data types.

User Action: Remove the % suffix from the variable name or change the data-type keyword.

SUFNOTALL, suffix not allowed on variable <name>

Explanation: ERROR - A name, which cannot end in a percent sign or dollar sign, such as a label name, ends with either a percent sign or dollar sign.

User Action: Remove the variable's percent or dollar sign.

SUFNOTHAN, suffix not allowed on HANDLER <name>

Explanation: ERROR - A HANDLER name ends in a percent or dollar sign.

User Action: Remove the percent or dollar sign from the HANDLER name.

SUFNOTREC, suffix not allowed for record type

Explanation: ERROR - A record definition specifies a user-defined record type that ends in a percent or dollar sign.

User Action: Remove the record type's percent or dollar sign.

SUFSTRONLY, $ is only allowed with STRING keyword

Explanation: ERROR - The $ suffix is only allowed on string data types.

User Action: Remove the $ suffix from the variable name or change the data-type keyword.

SYNNOTANS, syntax check mode not allowed when ANSI

Explanation: ERROR - A SET /SYNTAX_CHECK command was entered when the /ANSI_STANDARD qualifier was in effect.

User Action: None; syntax checking is not supported in ANSI mode.

SYSERROR, system service error

Explanation: ERROR - An error was detected while executing a system service.

User Action: Take corrective action based on the associated message.

TEXFOLEND, text following end of program unit must be on new <type of line> line

Explanation: ERROR - The compiler detected text following an END, END SUB, or END FUNCTION statement.

User Action: Remove the text. In a multimodule source file with line numbers, any text following an END, END SUB, or END FUNCTION statement must begin on a numbered line. In a multimodule source file without line numbers, any text following an END, END SUB, or END FUNCTION statement must begin on a new physical line.

TEXLINMSG, text line exceeded 255 characters

Explanation: INFORMATION - An input line contains more than 255 characters. VAX BASIC saves the first 255 input characters into the line buffer and ignores the rest of the input.

User Action: Supply no more than 255 characters per input line to avoid truncation of input.

TEXPATMUS, text path must be "RIGHT", "LEFT", "UP" or "DOWN"

Explanation: ERROR - You specified an invalid value for the path specification of the SET TEXT PATH statement.

User Action: Specify one of the values listed in the message.

TEXPREMUS, text precision must be "STROKE","CHAR" or "STRING"

Explanation: ERROR - You specified an invalid value for the text precision of the SET TEXT FONT statement.

User Action: Specify one of the values listed in the message.

THEMUSFOL, THEN directive must follow a lexical expression

Explanation: ERROR - A %IF directive contains a lexical expression that is not immediately followed by a %THEN clause.

User Action: Supply a %THEN clause. %THEN, %ELSE, and %END %IF are required in a %IF directive.

TOMCHINFO, extra information on command line has been ignored

Explanation: INFORMATION - You supplied an argument to a CONTINUE, EXIT, IDENTIFY, or SCRATCH command. These commands do not accept arguments. VAX BASIC ignores the extra data and executes the command.

User Action: Remove the argument from the command.

TOOFEWARG, too few arguments

Explanation: ERROR - The invocation of a VAX BASIC built-in function contains too few arguments.

User Action: Supply the correct number of arguments to the function.

TOOMANARG, too many arguments

Explanation: ERROR - The invocation of a VAX BASIC built-in function contains too many arguments.

User Action: Supply the correct number of arguments to the function.

TOOMANIND, too many array indices active

Explanation: ERROR - A subscript expression contains more than 100 array indices between the open parenthesis and the close parenthesis.

User Action: Reduce the number of active array indices.

TOOMANKEY, too many keys - limit is 255

Explanation: ERROR - An OPEN statement specifies more than 255 index keys.

User Action: Reduce the number of index keys. The maximum is 255.

TOOMANPAR, too many function parameters active

Explanation: ERROR - An external function invocation contains too many expressions in the actual parameter list.

User Action: Reduce the number of expressions in the actual parameter by assigning the expressions to temporary variables.

TRAFUNONL, Transformation functions only permitted with multiplication

Explanation: ERROR - A graphics transformation function is used in a MAT statement other than matrix multiplication.

User Action: Remove the transformation function from the MAT statement.

TRAOUTRAN, transformation number must be in the range 1 - 255

Explanation: ERROR - You specified a transformation number that is less than 1 or greater than 255.

User Action: Change the transformation number to be within the range 1 to 255.

TYPDEFSTR, TYPE default of STRING is not allowed.

Explanation: ERROR - STRING was specified as the default data type in: 1) a compiler command, 2) a qualifier to the DCL BASIC command, or 3) an OPTION statement.

User Action: Specify a numeric data type as the default.

UNDEFINED, unresolved/undefined symbols

Explanation: ERROR - A program executed in the BASIC environment calls or invokes a subprogram or routine that has not been loaded.

User Action: Load the subprogram or routine before running the program in the BASIC environment.

UNDLINNUM, undefined line number

Explanation: ERROR - A statement tries to transfer control to a nonexistent line. Or, in a numberless program, a line number is referenced.

User Action: Replace the nonexistent line number with the correct destination line number or label.

UNELEXDIR, unexpected lexical directive encountered

Explanation: ERROR - The specified lexical directive is not legal in this statement.

User Action: Use a supported lexical directive.

UNEXPEOF, unexpected end of file

Explanation: ERROR - An end-of-file was specified immediately after an ampersand continuation character.

User Action: Remove the ampersand continuation character or continue the line.

UNKCOMINP, unknown command input

Explanation: ERROR - An attempt was made to enter an invalid or unknown command.

User Action: Enter the VAX BASIC command correctly.

UNLINCREA, UNLOCK EXPLICIT clause inconsistent with ACCESS READ

Explanation: ERROR - An OPEN statement contains both an ACCESS READ and an UNLOCK EXPLICIT clause. This is inconsistent because ACCESS READ specifies no record locking while UNLOCK EXPLICIT specifies that all accessed records remain locked until explicitly unlocked.

User Action: Either remove the UNLOCK EXPLICIT clause or change the ACCESS clause.

UNSCDDLEV, unsupported CDD/Plus level <number>. Supported level is <number>.

Explanation: ERROR - The current CDD/Plus version is incompatible with VAX BASIC.

User Action: Use a supported version of CDD/Plus.

UNTSTRLIT, unterminated string literal

Explanation: ERROR - The program contains an improperly terminated string literal; for example, "ABC , "ABC', and 'ABC" are all improperly terminated.

User Action: Use the same type of quotation mark (either single or double) for both beginning and ending string delimiters.

USEONLALO, USE only allowed inside WHEN blocks

Explanation: ERROR - A USE statement is not within a WHEN block.

User Action: Remove the USE statement.

USERABORT, user ABORT directive <text>

Explanation: FATAL - The compilation was terminated as the result of a %ABORT directive. The compiler prints the text following the %ABORT.

User Action: None.

USERPRINT, <text>

Explanation: SUCCESS - The compilation found a %PRINT directive and printed the specified message to the terminal and listing file.

User Action: None.

USEVARNOT, user variable <name> not allowed in declaration

Explanation: ERROR - The parameter list in an external subprogram declaration contains a user variable name.

User Action: Remove the variable from the parameter list. When declaring a routine, the parameter list can contain only data type and parameter-passing mechanism specifications.

VALTOOLAR, value too large for constant

Explanation: WARNING - The value of an EXTERNAL CONSTANT is larger than the specified data type allows.

User Action: Make sure the data type specified in the EXTERNAL CONSTANT statement matches that of the actual constant.

VALUEREQ, PRINT USING requires a value

Explanation: ERROR - A PRINT USING statement must have at least one expression or value.

User Action: Supply an expression or value at the end of the PRINT USING statement.

VARCONREQ, variable or constant required

Explanation: ERROR - The program contains an executable DIM statement that contains an expression in the bounds list.

User Action: Remove the expression from the bounds list. Executable DIM statements can have only constants or variables (simple or subscripted) as bounds.

VERJUSMUS, vertical justification must be "TOP", "CAP","HALF","BASE", "BOTTOM" or "NORMAL"

Explanation: ERROR - You specified an invalid value for the vertical component of the SET TEXT JUSTIFY statement.

User Action: Specify one of the values listed in the message.

VIRARROVF, virtual array space exceeded at array <name>

Explanation: ERROR - The storage for virtual arrays on a single channel exceeds 2147483647 bytes.

User Action: If there is only one virtual array on the channel, you must reduce the amount of storage used by the array. However, if there is more than one virtual array on the channel, you can put each array on a separate channel.

VIRNOTALL, virtual array not allowed in graphics statements

Explanation: ERROR - You specified an entire virtual array on a statement that does not allow them.

User Action: Specify a nonvirtual array in place of the virtual array.

VIRRECTOO, virtual RECORD <name> is too large. Limit is 512 bytes

Explanation: ERROR - The elements of a virtual array are of type <name> and the total storage requirement for each element is greater than 512 bytes.

User Action: Reduce the size of the RECORD.

WRITEERR, error writing <file-name>

Explanation: ERROR - An error was detected in attempting to write to a file.

User Action: Supply a valid file specification or take corrective action based on the associated message.

WROTYPLIB, library <lib-name> is not an OBJECT or IMAGE library

Explanation: WARNING - The logical BASIC$LIBn translates to a library that is not an object library or a shareable image library.

User Action: Change the logical BASIC$LIBn to translate to an object library or a shareable image library.

XYPOIREQ, X,Y point required between semicolons

Explanation: ERROR - In a list of points in a statement such as PLOT LINES, you specified two semicolons in a row without an X,Y point specification between them.

User Action: Either supply another point or remove the extra semicolon.

Appendix B

Run-Time Error Messages

VAX BASIC returns run-time error messages if an error occurs while a program is executing. The error is diagnosed and for programs without line numbers, VAX BASIC indicates the program line that generated the error. Warning error messages indicate that an error has occurred, but program execution continues. In some cases, VAX BASIC reprompts for more information or correct data; in other cases, VAX BASIC performs the specified operation, but the results are not as expected. Fatal error messages indicate that the program has aborted. You can recover from most fatal errors by including error-handling routines in your program and by specifying OPTION HANDLE = FATAL. Certain errors, however, are not recoverable even when error-handlers are used. In the description of these errors they are designated as not trappable. You do not need error-handling routines to trap errors that generate warning messages.

Section B.1 of this appendix lists VAX BASIC run-time errors, alphabetized by mnemonic code. Section B.2 is a cross-reference numerical listing of run-time errors generated by VAX BASIC. Section B.3 lists error messages that VAX BASIC does not generate, but which can be displayed with the ERT$ function. See the *VAX BASIC Reference Manual* for information about RMSSTATUS and VMSSTATUS.

B.1 VAX BASIC Run-Time Errors By Mnemonic

The VAX BASIC error message format is:

```
%BAS-<l>-<mnemonic>, <message> -BAS-I-FROLINMOD, from Line x in module y
```

<l>
Is a letter indicating the severity of the error. The severity indicator can be:

- I, Indicating information
- W, Indicating a warning
- E, Indicating an error
- F, Indicating a severe error

<mnemonic>
Is a 3- to 9-character string that identifies the error.

<X>
Is the line number where the error occurred.

<Y>
Is the name of the module where the error occurred.

Warning error messages indicate that an error has occurred, but program execution continues. In some cases, VAX BASIC reprompts for more information or correct data; in other cases, VAX BASIC performs the specified operation, but the results are not as expected. Fatal error messages indicate that the program has aborted.

ARGDONMAT, Arguments don't match (ERR=88)

Explanation: The proper array descriptor was not specified for a matrix operation.

User Action: Use VAX BASIC to create the array.

ARGTOOLAR, Argument too large in EXP (ERR=49)

Explanation: The program contains:

- An argument to the EXP function larger than 88
- An exponentiation operation that results in a number greater than 1E38

User Action: Change the EXP argument to be in the valid range, or reduce the size of the exponent.

ARRMUSSAM, Arrays must be same dimension (ERR=238)

Explanation: The program attempts to perform matrix addition or subtraction on input arrays with a different dimensions.

User Action: Use arrays that have identical dimensions.

ARRMUSSQU, Arrays must be square (ERR=239)

Explanation: The program attempts matrix inversion (MAT INV) on an array that is not inversible.

User Action: Use only square arrays when performing a matrix inversion.

ARRTOOSMA, Array too small (ERR=197)

Explanation: The array you referenced with a graphics statement is too small. Check the description of the graphics statement to get the minimum size requirement for the array.

User Action: Increase the size of the array.

BADDIRDEV, Bad directory for device (ERR=1)

Explanation: The device directory does not exist or is unreadable.

User Action: Supply a valid directory.

BADRECIDE, Bad record identifier (ERR=143)

Explanation: The program attempted a record access that specified:

- A zero or negative record number on a RELATIVE file
- A null key value on an INDEXED file

User Action: Change the record number or key specification to a valid value.

BADRECVAL, Bad RECORDSIZE value on OPEN (ERR=148)

Explanation: The value in the RECORDSIZE clause in the OPEN statement either (1) is zero or greater than 65535 or (2) does not match the record size of an existing file.

User Action: Change the value in the RECORDSIZE clause.

CANCHAARR, Cannot change array dimensions (ERR=240)

Explanation: The program attempts to redimension an array to a different number of dimensions.

User Action: Change the arrays dimensions in the DIM or MAT statement.

CANFINFIL, Can't find file or account (ERR=5)

Explanation: The specified file or directory is not present on the device.

User Action: Supply a valid file specification.

CANINVMAT, Can't invert matrix (ERR=56)

Explanation: The program attempts to invert a single-dimension matrix.

User Action: Supply a matrix of the proper form for inversion.

CANOPEFIL, Cannot open file (ERR=162)

Explanation: The program attempts to open a file that cannot be opened.

User Action: Use VMSSTATUS to determine the RMS failure that caused the error.

CLIPONOFF, Clipping must be set to ON or OFF (ERR=259)

Explanation: Valid strings for the SET CLIP statement are "ON" and "OFF".

User Action: Change the string to either "ON" or "OFF".

COLNOTCON, Color indices are not contiguous (ERR=261)

Explanation: The color indices on the device you are using are not contiguous.

User Action: Unlike most devices, all color indices between zero and the number returned by the ASK MAX COLOR statement are not available on this device.

COONOTNDC, Coordinates are not within NDC space (ERR=273)

Explanation: The boundaries of NDC space are 0,1,0,1; coordinates must be within this range.

User Action: Supply coordinates with values between 0 and 1. Make sure that the minimum value of x is less than the maximum value of x and that the minimum value of y is less than the maximum value of y.

CORFILSTR, Corrupted file structure (ERR=29)

Explanation: RMS has detected an invalid file structure on disk.

User Action: See your system manager.

DATFORERR, Data format error (ERR=50)

Explanation: The program specifies a data type in a statement that does not agree with the value supplied or invalid data was used in string arithmetic.

User Action: Change the statement or supply data of the correct type.

DATOVERF, data overflow (ERR=289)

Explanation: The keystroke retrieved by the INKEY$ function caused the type-ahead buffer to overflow or the terminal attempted to send a valid ANSI escape sequence that did not correspond to a keystroke.

User Action: Specify the DCL command SET TERMINAL/HOSTSYNC, before using the INKEY$ function. This command will prevent the type-ahead buffer from overflowing.

DATTYPERR, Data type error (ERR=101)

Explanation: The program attempts to access a parameter passed BY DESC (by descriptor), and the descriptor contains an incorrect data type. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Check the program code that created the passed parameter and make sure it creates a parameter of correct data type.

DEADLOCK, Detected deadlock while waiting for GET or FIND (ERR=193)

Explanation: The record your program is trying to access is currently locked on another channel or by another process. Simultaneously, your program has locked a record that the other user cannot access. The deadlock cannot be resolved.

User Action: Possible solutions include:

- Use the FREE statement to unlock *all* locked records
- Use GET...REGARDLESS if read access is sufficient

DECERR, DECIMAL error or overflow (ERR=181)

Explanation: The result of a DECIMAL expression is greater than or requires more precision than can be contained in the variable.

User Action: Reduce the magnitude of the expression or increase the allowed digits in the DECIMAL variable.

User Action: Check program logic or trap the error in an error handler.

DEVHUNWRI, Device hung or write locked (ERR=14)

Explanation: The program attempted an operation to a hardware device that is not functioning properly or is protected against writing.

User Action: Check the device on which the operation is performed.

DEVINMET, Device is an input metafile (ERR=270)

Explanation: The operation cannot be performed on an input metafile (device type 3).

User Action: Specify the device ID for a device other than an input metafile.

DEVNOTOPE, Device is not open (ERR=268)

Explanation: The device has not been identified in an OPEN...FOR GRAPHICS statement.

User Action: Specify the device id number in an OPEN...FOR GRAPHICS statement.

DEVOPEINC, Device and operation are incompatible (ERR=272)

Explanation: The operation you requested cannot be performed on the specified device. For example, output cannot be dislayed on a device that is for input only.

User Action: Specify the device ID for a device with the appropriate compatibility. Device types are listed in *Programming with VAX BASIC Graphics*.

DEVOUTMET, Device is an output metafile (ERR=269)

Explanation: The specified device is an output metafile (device type 2).

User Action: Specify the device ID for a device other than an output metafile.

DEVTYPNOT, Device type is not supported (ERR=267)

Explanation: The specified device type is not supported by DEC GKS FOR VMS.

User Action: Specify an alternative device type. Standard supported device types are listed in *Programming with VAX BASIC Graphics* and in the DEC GKS FOR VMS documentation. Verify with your system manager that support for the specified device has been installed. Also, verify that the DEC GKS FOR VMS startup command procedure has properly executed.

DIFUSELON, Differing use of LONG/WORD or SINGLE/DOUBLE qualifiers (ERR=229)

Explanation: The main and subprograms were compiled with different LONG/WORD modes. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Recompile one of the programs with the same qualifier as the other.

DIMOUTRAN, Dimension number out of range (ERR=195)

Explanation: The upper or lower bound of the specified dimension cannot be returned because the array has fewer dimensions than the one requested.

User Action: Change the dimensions specified with the LBOUND or UBOUND function.

DIRERR, Directive error (ERR=253)

Explanation: A system service call resulted in an error.

User Action: See the *VMS I/O User's Reference Volume* or the *VMS Record Management Services Manual.*

DIVBY_ZER, Division by 0 (ERR=61)

Explanation: The program attempts to divide a value by zero.

User Action: Check program logic and change the attempted division or trap the error in an error handler.

DUPKEYDET, Duplicate key detected (ERR=134)

Explanation: In a PUT operation to an indexed file, a duplicate key was specified, and DUPLICATES was not specified when the file was created.

User Action: Change the duplicate key, or re-create the file specifying DUPLICATES for that key.

ECHTYPNOT, Prompt/echo type not supported (ERR=256)

Explanation: The specified prompt or echo type is invalid. VAX BASIC supports only the default prompt and echo types.

User Action: Do not change the prompt or echo type. If you do so, you should continue to use direct calls to DEC GKS FOR VMS routines rather than use VAX BASIC input statements.

ENDFILDEV, End of file on device (ERR=11)

Explanation: The program attempted to read data beyond the end of the file.

User Action: None. The program can trap this error in an error handler.

ENTPOINOT, Entered points not within a transformation (ERR=285)

Explanation: Input points are not within the viewport of a defined transformation.

User Action: Issue a warning to the user to input points within the defined area. Alternatively, you can change at least one transformation to include the viewport area not defined. At the start of program execution, transformation 1 includes all of NDC space. Optionally, you can define one transformation to cover the default viewport.

ERRFILCOR, Error on OPEN - file corrupted (ERR=178)

Explanation: The program attempted to open an invalid structure on disk.

User Action: See your system manager.

ERRTRANEE, ERROR trap needs RESUME (ERR=246)

Explanation: An error handler attempts to execute an END, END SUB, END FUNCTION, SUBEND, FUNCTIONEND, or FNEND statement without first executing a RESUME statement. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Change the program logic so that the error handler executes a RESUME statement before executing an END, END SUB, END DEF, SUBEND, FUNCTIONEND, or FNEND statement.

FATSYSIO_, Fatal system I/O failure (ERR=12)

Explanation: An I/O error has occurred in: (1) the system or (2) Record Management Services. The last operation will not be completed.

User Action: See the *VMS System Messages and Recovery Procedures* for RMS errors or retry the operation. Use VMSSTATUS to return the VMS condition code that caused the error.

FIEOVEBUF, FIELD overflows buffer (ERR=63)

Explanation: A FIELD statement attempts to access more data than exists in the specified buffer.

User Action: Change the FIELD statement to match the buffer's size, or increase the buffer's size.

FILACPFAI, FILE ACP failure (ERR=252)

Explanation: The operating system's file handler reported an error to RMS.

User Action: See the *VMS I/O User's Reference Volume* or the *VMS Record Management Services Manual.*

FILATTNOT, File attributes not matched (ERR=160)

Explanation: The following attributes in the OPEN statement do not match the corresponding attributes of the target file:

- ORGANIZATION
- BUCKETSIZE
- BLOCKSIZE

- Key number, size, position, or attributes (CHANGES and DUPLICATES)
- Record format

User Action: Change the OPEN statement attributes to match those of the file or remove the clause.

FILEXPDAT, File expiration date not yet reached (ERR=174)

Explanation: The program attempted to delete a file before the file's expiration date was reached.

User Action: Change the file's expiration date.

FILIS_LOC, File is locked (ERR=138)

Explanation: The program does not allow shared access, and attempts to access a file that has been locked by another user or by the system.

User Action: Change the OPEN statement to allow shared access or wait until the file is released by other users.

FLOPOIERR, Floating point error or overflow (ERR=48)

Explanation: A program operation resulted in a floating-point number with absolute value outside the allowable range for that data type.

User Action: Check program logic or trap the error in an error handler.

FNEWITFUN, FNEND without function call (ERR=73)

Explanation: The program executes an END DEF or FNEND statement before executing a function call. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Check program logic to make sure that END DEF or FNEND statements are executed only in multiline DEFs or remove the END DEF or FNEND statement.

GKSNOTINS, DEC GKS FOR VMS is not installed (ERR=226)

Explanation: Graphics statements are not operational when DEC GKS FOR VMS is not installed.

User Action: See your system manager.

ILLALLCLA, Illegal ALLOW clause (ERR=168)

Explanation: The value specified for the ALLOW clause (sharing) on the OPEN statement is illegal for the type of file organization.

User Action: Change the ALLOW clause argument.

ILLARGLOG, Illegal argument in LOG (ERR=53)

Explanation: The program contains a negative or zero argument to the LOG or LOG10 function.

User Action: Supply an argument in the valid range.

ILLARESTY, Illegal area style (ERR=262)

Explanation: Area style must be one of the following:

- SOLID (the default)
- HOLLOW
- HATCH
- PATTERN

User Action: Specify a valid area style for the device.

ILLBYTCOU, Illegal byte count for I/O (ERR=31)

Explanation: A PRINT or INPUT list invoked a function that closed an I/O channel.

User Action: Change the function so that it does not close the I/O channel.

ILLCNTCLA, Illegal count clause (ERR=290)

Explanation: In a graphics statement, you specified a COUNT clause with a numeric value which exceeds the size of the array.

User Action: Specify a numeric value which is less than or equal to the size of the array.

ILLCOLIND, Illegal color index (ERR=280)

Explanation: The index you specified is not supported by the device.

User Action: Specify a valid color index. The valid range of indices for the device is from 0 to the value retrieved by the ASK MAX COLOR statement.

ILLCOLMIX, Illegal color mix (ERR=291)

Explanation: The color mix value specified on the SET COLOR MIX statement is outside the range of 0 to 1.

User Action: Specify a value between 0 and 1.

ILLDEVID, Illegal device identification number (ERR=266)

Explanation: The device identification number is beyond the valid range of 0 through 255.

User Action: Specify a device identification number between 0 and 255.

ILLDEVNAM, Illegal device name in OPEN (ERR=292)

Explanation: An explicit or implicit OPEN...FOR GRAPHICS statement contains an illegal device name for the device type being used. Possible causes include:

- Specifying a device that does not exist on the system
- Specifying a logical name that is not defined
- Specifying a file name that does not exist when the device type is for an input metafile
- Specifying a file name for a device type that requires a VMS physical device name

User Action: Specify an appropriate device name.

ILLECHARE, Illegal echo area (ERR=283)

Explanation: The specified echo area boundaries are invalid.

User Action: Specify echo area boundaries within the device viewport.

ILLEXIDEF, Illegal exit from DEF* (ERR=245)

Explanation: A multiline DEF* contains a branch to an END, END SUB, END DEF, SUBEND, or FUNCTIONEND statement. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Change the program logic so that the program executes the multiline function's END DEF or FNEND statement before executing the END, END SUB, END DEF, SUBEND, or FUNCTIONEND statement.

ILLFIEVAR, Illegal FIELD variable (ERR=122)

Explanation: A FIELDed variable is referenced after a non-BASIC subprogram closed the file associated with that variable. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = SEVERE.

User Action: Check program logic; do not reference the variable after the file has been closed.

ILLFILNAM, Illegal file name (ERR=2)

Explanation: A file name is: (1) too long, (2) incorrectly formatted, or (3) contains embedded blanks or invalid characters.

User Action: Supply a valid file specification.

ILLILLACC, Illegal or illogical access (ERR=136)

Explanation: The requested access is impossible because:

- The attempted record operation and the ACCESS clause in the OPEN statement are incompatible.
- The ACCESS clause is inconsistent with the file organization.
- ACCESS READ or APPEND was specified when the file was created.

User Action: Change the ACCESS clause.

ILLINIVAL, Illegal initial value (ERR=284)

Explanation: The current initial value specified on the SET INITIAL VALUE or LOCATE VALUE statement is beyond the range of possible values.

User Action: Specify an initial value within the default range (0 through 1) or within the alternative range you optionally specified, or change the range limits.

ILLIO_CHA, Illegal I/O channel (ERR=46)

Explanation: The program specified an I/O channel outside the legal range.

User Action: Specify I/O channels in the range 1 to 99, inclusive or one returned from LIB$GET_LUN.

ILLKEYATT, Illegal key attributes (ERR=137)

Explanation: The program specified CHANGES for the primary key.

User Action: Remove the CHANGES specification from the primary key. You can specify CHANGES only for alternate keys.

ILLLINSIZ, Illegal line size (ERR=275)

Explanation: The specified line size is less than or equal to zero.

User Action: Specify a line size value greater than zero.

ILLLINSTY, Illegal line style number (ERR=274)

Explanation: The specified line style number is less than or equal to zero.

User Action: Specify a valid line style value greater than zero.

ILLNETOPE, Illegal network operation (ERR=190)

Explanation: The program tries to mix GET and PUT operations, or PRINT and INPUT operations, on a remote terminal-format file.

User Action: Change the file organization when opening the file to be sequential variable.

ILLNUM, Illegal number (ERR=52)

Explanation: A value supplied to a numeric variable is incorrect, for example "ABC" and "1..2" are illegal numbers.

User Action: Supply numeric values of the correct form.

ILLOPE, Illegal operation (ERR=141)

Explanation: The program attempts to:

- DELETE a record in a sequential file
- UPDATE a record on a magtape file
- Rewind a process-permanent file
- DELETE a record in a read-only file
- Assign a value to a virtual array element in a read-only file
- Perform a MARGIN operation on VIRTUAL file
- Transpose a matrix, or perform a matrix multiplication, with the same array as source and destination

- Perform an invalid operation on a VIRTUAL file, for example, using GET and PUT on a VIRTUAL file, then attempting to reference a virtual array dimensioned on that file

User Action: Change the illegal operation.

ILLPICOPE, Illegal picture operation (ERR=258)

Explanation: The program attempts to change a transformation within a picture definition. The following statements are invalid within pictures and within routines that are called by pictures:

- SET WINDOW
- SET VIEWPORT
- SET DEVICE WINDOW
- SET DEVICE VIEWPORT
- SET TRANSFORMATION
- SET INPUT PRIORITY
- SET CLIP

User Action: Remove any invalid statements from the picture definition. Set the boundaries for windows and viewports before a picture is invoked.

ILLPOISTY, Illegal point style number (ERR=276)

Explanation: The specified point style is less than or equal to zero.

User Action: Specify a valid point style greater than or equal to zero.

ILLRECACC, Illogical record accessing (ERR=152)

Explanation: The program attempts to perform an operation that is invalid for the specified file type, for example, a random access on a sequential file.

User Action: Supply a valid operation for that file type or change the file type.

ILLRECFIL, Illegal record on file (ERR=142)

Explanation: A record contains an invalid byte count field.

User Action: Use the DCL command DUMP to check the file for possible bad data.

ILLRECLOC, illegal record locking (ERR=187)

Explanation: The program contains an ALLOW clause on a GET statement and the file was not opened with the UNLOCK EXPLICIT clause. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Either remove the ALLOW clause from the GET statement or use the EXPLICIT UNLOCK clause in the OPEN statement.

ILLRESSUB, Illegal RESUME to subroutine (ERR=247)

Explanation: While in an error handler activated by an ON ERROR GO BACK, the error handler attempts to RESUME without a line number. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: None; you cannot specify the RESUME statement without a line number in any program module except in the program module containing the error handler.

ILLSTYIND, Illegal area style index (ERR=279)

Explanation: The specified area style index is less than or equal to zero.

User Action: Specify a valid area style index greater than zero.

ILLSWIUSA, Illegal switch usage (ERR=67)

Explanation: The program attempts an illegal SYS call.

User Action: See the appropriate RSTS/E SYS call documentation.

ILLSYSUSA, Illegal SYS usage( ) (ERR=18)

Explanation: The program attempted an illegal SYS call.

User Action: See the appropriate RSTS/E SYS call documentation.

ILLTEXHEI, Illegal text height (ERR=278)

Explanation: The text height is less than or equal to zero.

User Action: Specify a text height greater than zero.

ILLTEXJUS, Illegal text justification (ERR=263)

Explanation: The specified text justification factor is invalid.

User Action: See *Programming with VAX BASIC Graphics* for valid justification values. Specify valid values.

ILLTEXPAT, Illegal text path (ERR=265)

Explanation: The specified text path is invalid.

User Action: Specify a valid text path. Valid text path values are:

- RIGHT (the default)
- LEFT
- UP
- DOWN

ILLTEXPRE, Illegal text precision (ERR=264)

Explanation: The specified precision string is invalid.

User Action: Valid precision values are: "STROKE" for software fonts, "STRING" and "CHAR" for hardware fonts. Specify a valid string for the precision value.

ILLTEXRAT, Illegal text width-to-height ratio (ERR=276)

Explanation: The specified width-to-height ratio is less than or equal to zero.

User Action: Specify a width-to-height ratio greater than zero.

ILLTFFOPE, Illegal terminal-format file operation (ERR=191)

Explanation: The program specifies a GETRFA function on a terminal-format file.

User Action: Change the file organization when opening the file to be sequential variable.

ILLTRANUM, Illegal transformation number (ERR=257)

Explanation: The specified tranformation number is less than 1 or greater than 255.

User Action: Specify a transformation number between 1 and 255.

ILLUSADEV, Illegal usage for device (ERR=133)

Explanation: The requested operation cannot be performed because:

- The device specification contains illegal syntax
- The specified device does not exist on your system
- The specified device is inappropriate for the requested operation (for example, an indexed file access on magnetic tape)

User Action: Supply the correct device type.

ILLWAIVAL, Illegal wait value (ERR=192)

Explanation: The specified integer expression on the WAIT clause is less than zero or greater than 255.

User Action: Specify an integer expression whose value is 0 through 255.

IMASQUROO, Imaginary square roots (ERR=54)

Explanation: An argument to the SQR function is negative.

User Action: Supply arguments to the SQR function that are greater than or equal to zero.

IMPERRHAN, improper error handling (ERR=186)

Explanation: After an error has occurred, a program's error handler calls another program unit, and the called program unit executes an ON ERROR GO BACK statement before clearing the error with a RESUME statement. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Change the program logic so that the called program clears the error condition before executing the ON ERROR GO BACK statement.

INDNOTFUL, Index not fully optimized (ERR=170)

Explanation: A record was successfully written to an INDEXED file; however, the alternate key path was not optimized. This slows record access.

User Action: Delete the record and rewrite it.

INTERR, Integer error (ERR=51)

Explanation: The program contains an integer whose absolute value is greater than 255 in BYTE mode, 32767 in WORD mode, or 2147483647 in LONG mode.

User Action: Use an integer in the valid range for specified data type.

INVCHASTR, Invalid character in string (ERR=287)

Explanation: The program attempts to output a string that contains an invalid character.

User Action: Remove the invalid character from the string.

INVFILOPT, Invalid file options (ERR=139)

Explanation: The program has specified invalid file options in the OPEN statement.

User Action: Change the invalid file options.

INVKEYREF, Invalid key of reference (ERR=144)

Explanation: The program attempts to perform a GET, FIND, or RESTORE on an INDEXED file using an invalid KEY, for example, an alternate KEY that does not exist for the file that was opened.

User Action: Use a valid KEY in the GET, FIND, or RESTORE statement.

INVRFAFIE, Invalid RFA field (ERR=173)

Explanation: During a FIND or GET by RFA, an invalid record's file address was specified.

User Action: Supply a correct RFA field.

IO_CHAALR, I/O channel already open (ERR=7)

Explanation: The program attempted to open a channel that had already been opened and the implicit close failed.

User Action: Submit an SPR.

IO_CHANOT, I/O channel not open (ERR=9)

Explanation: The program attempted to perform an I/O operation before opening the channel.

User Action: Open the channel before attempting an I/O operation to it.

KEYFIEBEY, Key field beyond end of record (ERR=151)

Explanation: The position given for the key field exceeds the maximum size of the record.

User Action: Specify a key field within the record.

KEYLARTHA, Key larger than record (ERR=159)

Explanation: The key specification exceeds the maximum record size.

User Action: Reduce the size of the key specification.

KEYNOTCHA, Key not changeable (ERR=130)

Explanation: An UPDATE statement attempted to change a key field that did not have CHANGES specified in the OPEN statement.

User Action: Remove the changed key field in the UPDATE statement or specify CHANGES for that key field in the OPEN statement. Note that the primary key cannot be changed and that you cannot specify CHANGES when you open an existing file if the OPEN statement that created the file did not specify CHANGES.

KEYSIZTOO, Key size too large (ERR=145)

Explanation: The key length on a GET or FIND is either zero or larger than the key length defined for the target record.

User Action: Change the key specification in the GET or FIND statement.

KEYWAIEXH, Keyboard wait exhausted (ERR=15)

Explanation: No input was received during the execution of an INPUT, LINPUT, or INPUT LINE statement that was preceded by a WAIT statement or INKEY$ timeout value.

User Action: None; you must supply input within the specified time.

LINTOOLON, Line too long (ERR=47)

Explanation: The program attempted to input more data than the input buffer can hold. The default input buffer size for terminal input is 132.

User Action: Either decrease the amount of data entered at one time, or increase the size of the input buffer. You can explicitly OPEN the input device and specify the input buffer size with the RECORDSIZE or MAP clause.

MATDIMERR, Matrix dimension error (ERR=124)

Explanation: The program:

- Attempts to assign more than two dimensions to an array
- Attempts to reference an array with fewer or more subscripts than there are dimensions in the array
- Attempts to redimension an array that cannot be redimensioned

This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Change the number of array subscripts. Reference the array using the correct number of dimensions, or change the array so that it can be redimensioned.

MAXMEMEXC, Maximum memory exceeded (ERR=126)

Explanation: The program has insufficient string and I/O buffer space because: (1) its allowable memory size has been exceeded, or (2) the system's maximum memory capacity has been reached. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Reduce the amount of string or I/O buffer space, or split the program into two or more programs.

MEMMANVIO, Memory management violation (ERR=35)

Explanation: The program attempted to read or write to a memory location to which it was not allowed access. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: If the program was compiled with /NOCHECK, it may be exceeding an array bound; recompile with /CHECK. Otherwise, check program logic.

MISSPEFEA, Missing special feature (ERR=66)

Explanation: The program attempts to use an unavailable SYS call.

User Action: See the appropriate RSTS/E SYS call documentation.

MOVOVEBUF, Move overflows buffer (ERR=161)

Explanation: In a MOVE statement, the combined length of elements in the I/O list exceeds the size of the record just read or the size of the buffer.

User Action: Reduce the size of the I/O list or increase the file's RECORDSIZE.

NEGFILSTR, Negative fill or string length (ERR=166)

Explanation: A MOVE statement I/O list contains a FILL item or string length with a negative value.

User Action: Change the FILL item or string length value to be greater than or equal to zero.

NEGZERTAB, negative or zero TAB (ERR=176)

Explanation: The program attempted a zero or negative TAB. This error is signaled only for programs compiled with the /ANSI_STANDARD qualifier.

User Action: Change the argument to the TAB statement.

NETOPERR, network operation error (ERR=182)

Explanation: The program attempts to perform an invalid network operation, or the network software failed during a network operation.

User Action: Take action based on the associated error messages.

NODNAMERR, Node name error (ERR=175)

Explanation: A file specification's node name contains a syntax error.

User Action: Supply a valid node name.

NOTBASIC, Not a BASIC error (ERR=194)

Explanation: The error is not a VAX BASIC error and is not mapped to an alternative VAX BASIC error message.

User Action: Use RMSSTATUS or VMSSTATUS to access the text of the error message.

NOTENDFIL, Not at end of file (ERR=149)

Explanation: The program attempted a PUT operation: (1) on a sequential or relative file before the last record, or (2) without opening the file for WRITE access.

User Action: OPEN a sequential or relative file with ACCESS APPEND or OPEN the file with ACCESS WRITE.

NOTENODAT, Not enough data in record (ERR=59)

Explanation: An INPUT statement did not find enough data in one line to satisfy all the specified variables.

User Action: Supply enough data in the record or reduce the number of specified variables.

NOTIMP, Not implemented (ERR=250)

Explanation: The program attempted to use a feature that does not exist in this version of VAX BASIC for example, TIME(4%).

User Action: Do not use the feature.

NOTRANACC, Not a random access device (ERR=64)

Explanation: The program attempts a random access on a device that does not allow such access; for example, a PUT with a record number to a magtape file.

User Action: Make the access sequential instead of random or use a suitable I/O device.

NO_CURREC, No current record (ERR=131)

Explanation: The program attempts a DELETE or UPDATE when the previous GET or FIND failed, or no previous GET or FIND was done.

User Action: Correct the cause of failure for the previous GET or FIND, or make sure a GET or FIND was done, then retry the operation.

NO_PRIKEY, No primary key specified (ERR=150)

Explanation: The program attempts to create an INDEXED file without specifying a PRIMARY KEY value.

User Action: Specify a PRIMARY KEY.

NO_ROOUSE, No room for user on device (ERR=4)

Explanation: No user storage space exists on the specified device.

User Action: Delete files that are no longer needed.

NUMCOOINS, Number of coordinates insufficient (ERR=281)

Explanation: Insufficient coordinates are provided. A GRAPH POINTS statement requires the coordinates for at least one point. A GRAPH LINES statement requires a minimum of two points. A GRAPH AREA statement requires a minimum of three points.

User Action: Supply an adequate number of points.

ONEOR_TWO, One or two dimensions only (ERR=102)

Explanation: The program contains a MAT statement that attempts to assign more than two dimensions to an array. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Change the number of dimensions in the MAT statement to one or two.

ON_STAOUT, ON statement out of range (ERR=58)

Explanation: The index value in an ON GOTO or ON GOSUB statement is less than one or greater than the number of line numbers in the list.

User Action: Check program logic to make sure that the index value is greater than or equal to one, and less than or equal to the number of line numbers in the ON GOTO or ON GOSUB statement.

OUTOF_DAT, Out of data (ERR=57)

Explanation: A READ statement requested additional data from an exhausted DATA list.

User Action: Remove the READ statement, reduce the number of variables in the READ statement, or supply more DATA items.

PRIKEYOUT, Primary key out of sequence (ERR=158)

Explanation: RMS has detected an error in a sequential PUT to an INDEXED file.

User Action: Change the PUT statement. If this does not work, the file is corrupted and you cannot do anything.

PRIUSIFOR, PRINT-USING format error (ERR=116)

Explanation: The program contains a PRINT USING statement with an invalid format string.

User Action: Change the PRINT USING format string.

PROC_TRA, Programmable ^C trap (ERR=28)

Explanation: A CTRL/C was typed at the controlling terminal.

User Action: None; however, you can trap this error with an error handler.

PROLOSSOR, Internal error in VAX BASIC Run-Time Library. Please submit an SPR. (ERR=103)

Explanation: A consistency check in the VAX BASIC run-time support failed. Program execution is aborted. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: This error should never occur. Submit a Software Performance Report.

PROVIO, Protection violation (ERR=10)

Explanation: The program attempted to read or write to a file whose protection code did not allow the operation.

User Action: Use a different file or change the file's protection code or the attempted operation.

RECALREXI, Record already exists (ERR=153)

Explanation: An attempted random access PUT on a relative file has encountered a preexisting record.

User Action: Specify a different record number for the PUT or delete the record.

RECATTNOT, Record attributes not matched (ERR=228)

Explanation: A RECORDTYPE clause specifies record attributes that do not match those of the file.

User Action: Change the RECORDTYPE attribute to match that of the file.

RECBUCLOC, Record/bucket locked (ERR=154)

Explanation: The program attempts to access a record or bucket that has been locked by another program.

User Action: Retry the operation.

RECFILTOO, Record on file too big (ERR=157)

Explanation: The specified record is longer than the input buffer.

User Action: Increase the input buffer's size.

RECHASBEE, Record has been deleted (ERR=132)

Explanation: A record previously located by its Record File Address (RFA) has been deleted.

User Action: None.

RECNOTFOU, Record not found (ERR=155)

Explanation: A random access GET or FIND was attempted on a deleted or nonexistent record.

User Action: None.

RECNUMEXC, RECORD number exceeds maximum (ERR=147)

Explanation: The specified record number exceeds the maximum specified for this file.

User Action: Reduce the specified record number. The maximum record number cannot be specified in VAX BASIC; it is either a default, or it was specified by a non-BASIC program when the file was created.

RECOVEMAP, RECORDSIZE overflows MAP buffer (ERR=185)

Explanation: The OPEN statement specifies a RECORDSIZE value larger than the size of the MAP specified in the MAP clause. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Increase the size of the MAP to match the RECORDSIZE value.

REDARR, Redimensioned array (ERR=105)

Explanation: A MAT statement attempts to redimension an array to have more elements than were originally dimensioned.

User Action: Change the statement that attempts the redimension or increase the original number elements.

REMOVEBUF, REMAP overflows buffer (ERR=183)

Explanation: A REMAP statement causes the variables in the dynamic MAP to be associated with nonexistent storage.

User Action: Change the REMAP statement so that all variables are associated with the storage in the MAP.

REMSTRNOT, REMAP string is not static (ERR=196)

Explanation: The program referenced a string with a REMAP statement that was not declared in COMMON or MAP.

User Action: Declare the string in the COMMON or MAP statement.

RESNO_ERR, RESUME and no error (ERR=104)

Explanation: The program executes a RESUME statement without a line number outside of the error handling routine. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Check program logic to make sure that the RESUME statement is executed only in the error handler.

RETWITGOS, RETURN without GOSUB (ERR=72)

Explanation: The program executes a RETURN statement before a GOSUB. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Check program logic to make sure that RETURN statements are executed only in subroutines or remove the RETURN statement.

RRVNOTFUL, RRV not fully updated, (ERR=171)

Explanation: RMS wrote a record successfully, but did not update one or more Record Retrieval Vectors. Therefore, you cannot retrieve any records associated with those vectors.

User Action: Delete the record and rewrite it.

SCAFACINT, SCALE factor interlock (ERR=127)

Explanation: A subprogram was compiled with a different SCALE factor than that of the calling program. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Recompile one of the programs with a scale factor that matches the other.

SIZRECINV, Size of record invalid (ERR=156)

Explanation: The program contains a COUNT or RECORDSIZE specification that is invalid because:

- COUNT equals zero
- COUNT exceeds the maximum size of the record
- COUNT conflicts with the actual size of the current record during a sequential file UPDATE on disk
- COUNT does not equal the record size for fixed format records
- You specified a record size in the OPEN statement that was unequal to the actual record size established when the file was created.

User Action: Supply a valid COUNT value in the PUT or UPDATE statement, or a valid RECORDSIZE in the OPEN statement, whichever is applicable.

STO, Stop (ERR=123)

Explanation: The program executed a STOP statement. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = INFO or a greater severity.

User Action: Continue execution by typing CONTINUE or terminate execution by typing EXIT.

STRLENZER, string length is zero (ERR=288)

Explanation: A graphics statement references a null string where a null string is illegal.

User Action: Adjust the string length so that it is greater than zero.

STRTOOLON, String too long (ERR=227)

Explanation: The program attempts to create a string longer than 65535 bytes.

User Action: Reduce the length of the string.

SUBOUTRAN, Subscript out of range (ERR=55)

Explanation: The program attempts to reference an array element outside of the array's dimensioned bounds.

User Action: Check program logic to make sure that all array references are to elements within the array boundaries.

TAPBOTDET, Tape BOT detected (ERR=129)

Explanation: The program attempts a rewind or backspace operation on a magnetic tape that is already at the beginning of the file.

User Action: Trap the error or check program logic; do not rewind or backspace if the magnetic tape is at the beginning of the file.

TAPNOTANS, Tape not ANSI labeled (ERR=146)

Explanation: The program attempts to access a file-structured magnetic tape that does not have an ANSI label.

User Action: Determine the magnetic tape's format by mounting it with the /FOREIGN qualifier and using the DCL DUMP command. You can then access it as a nonfile-structured magnetic tape.

TAPRECNOT, Tape records not ANSI (ERR=128)

Explanation: The records in the magtape you accessed are neither ANSI D nor ANSI F format.

User Action: Determine the magtape's format by mounting it with the /FOREIGN qualifier and using the DCL DUMP command.

TERFORFIL, Terminal format file required (ERR=164)

Explanation: The program attempted to use PRINT #, INPUT #, LINPUT #, MAT INPUT #, MAT PRINT #, or PRINT USING # to access a RELATIVE, INDEXED, or VIRTUAL file.

User Action: Supply a terminal-format file.

TOOFEWARG, Too few arguments (ERR=97)

Explanation: A function invocation, CALL, or DRAW statement passed fewer arguments than were defined in the function, picture, DEF, DEF*, or subprogram. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Change the number of arguments to match the number defined in the function or subprogram.

TOOLITDAT, too little data in record (ERR=189)

Explanation: An INPUT statement did not find enough data in one line to satisfy all the specified variables. This error is signaled only for programs compiled with the /ANSI_STANDARD qualifier.

User Action: Supply enough data in the record, or reduce the number of specified variables.

TOOMANARG, Too many arguments (ERR=89)

Explanation: A function invocation, CALL, or DRAW statement passed more arguments than were expected. This error cannot be trapped with a VAX BASIC error handler unless the program contains OPTION HANDLE = FATAL.

User Action: Reduce the number of arguments. A SUB or FUNCTION subprogram can pass a maximum of 255 arguments; a DEF function call can pass a maximum of eight arguments.

TOOMUCDAT, too much data in record (ERR=177)

Explanation: The user has given too many items in response to the INPUT statement. This error is only signaled for ANSI INPUT.

User Action: Supply the correct number of items to the INPUT statement or change the INPUT statement.

TRANOTDIF, Transformation numbers are not different (ERR=260)

Explanation: The same transformation number is used twice in the SET INPUT PRIORITY statement.

User Action: Specify two different transformations in the SET INPUT PRIORITY statement.

UNEFILDAT, unexpired file date (ERR=179)

Explanation: The program attempts to delete a file whose expiration date has not yet passed.

User Action: None.

UNINUMNOT, Unit number is not defined for the device (ERR=282)

Explanation: The specified unit is a method that is not supported by the device. (The default unit is 1.)

User Action: Verify the supported units for the device and specify a valid unit.

UNKGKSERR, Unknown DEC GKS FOR VMS error (ERR=286)

Explanation: A graphics error has occurred that is not mapped to a VAX BASIC error message.

User Action: Use VMSSTATUS to access the text of the DEC GKS FOR VMS error message.

USEABOINP, User aborted input, locate point cancelled (ERR=293)

Explanation: ERROR - The middle mouse button was pressed during the execution of a graphics input statement that uses a mouse to enter points (for example, LOCATE POINT). The pressing of the middle mouse button aborts the graphics input statement in progress and the data in the variables used for the graphics input statement is unchanged.

The pressing of the middle mouse button during a graphics input statement is analogous to typing CTRL/Z at a regular INPUT statement.

User Action: None. The program can trap this error in an error handler and attempt the input statement again if so desired.

VIRARRDIS, Virtual array not on disk (ERR=43)

Explanation: The program attempted to reference a virtual array on a nondisk device, or the virtual array is not opened as ORGANIZATION VIRTUAL.

User Action: Virtual arrays must be on disk; change the file specification in the OPEN statement for this array. Open the file with ORGANIZATION VIRTUAL.

VIRARROPE, Virtual array not yet open (ERR=45)

Explanation: The program attempted to reference a virtual array before opening the associated disk file.

User Action: Open the disk file containing the virtual array before referencing the array.

VIRBUFTOO, Virtual buffer too large (ERR=42)

Explanation: The program attempted to access a VIRTUAL file and the buffer size was not 512 bytes.

User Action: Change the I/O buffer to be a multiple of 512 bytes.

B.2 VAX BASIC Run-time Errors By Number

1	BADDIRDEV, Bad directory for device
2	ILLFILNAM, Illegal file name
4	NO_ROOUSE, No room for user on device
5	CANFINFIL, Can't find file or account
7	IO_CHAALR, I/O channel already open
9	IO_CHANOT, I/O channel not open
10	PROVIO, Protection violation
11	ENDFILDEV, End of file on device

12	FATSYSIO_, Fatal system I/O failure
14	DEVHUNWRI, Device hung or write locked
15	KEYWAIEXH, Keyboard wait exhausted
18	ILLSYSUSA, Illegal SYS( ) usage
28	PROC__TRA, Programmable ^C trap
29	CORFILSTR, Corrupted file structure
31	ILLBYTCOU, Illegal byte count for I/O
35	MEMMANVIO, Memory management violation
42	VIRBUFTOO, Virtual buffer too large
43	VIRARRDIS, Virtual array not on disk
45	VIRARROPE, Virtual array not yet open
46	ILLIO_CHA, Illegal I/O channel
47	LINTOOLON, Line too long
48	FLOPOIERR, Floating point error or overflow
49	ARGTOOLAR, Argument too large in EXP
50	DATFORERR, Data format error
51	INTERR, Integer error
52	ILLNUM, Illegal number
53	ILLARGLOG, Illegal argument in LOG
54	IMASQUROO, Imaginary square roots
55	SUBOUTRAN, Subscript out of range
56	CANINVMAT, Can't invert matrix
57	OUTOF_DAT, Out of data
58	ON_STAOUT, ON statement out of range
59	NOTENODAT, Not enough data in record
61	DIVBY_ZER, Division by 0
63	FIEOVEBUF, FIELD overflows buffer
64	NOTRANACC, Not a random access device
66	MISSPEFEA, Missing special feature
67	ILLSWIUSA, Illegal switch usage
72	RETWITGOS, RETURN without GOSUB
73	FNEWITFUN, FNEND without function call
88	ARGDONMAT, Arguments don't match

89	TOOMANARG, Too many arguments
97	TOOFEWARG, Too few arguments
101	DATTYPERR, Data type error
102	ONEOR_TWO, One or two dimensions only
103	PROLOSSOR, Internal error in VAX Run-Time Library. Please submit an SPR.
104	RESNO_ERR, RESUME and no error
105	REDARR, Redimensioned array
116	PRIUSIFOR, PRINT-USING format error
122	ILLFIEVAR, Illegal FIELD variable
123	STO, Stop
124	MATDIMERR, Matrix dimension error
126	MAXMEMEXC, Maximum memory exceeded
127	SCAFACINT, SCALE factor interlock
128	TAPRECNOT, Tape records not ANSI
129	TAPBOTDET, Tape BOT detected
130	KEYNOTCHA, Key not changeable
131	NO_CURREC, No current record
132	RECHASBEE, Record has been deleted
133	ILLUSADEV, Illegal usage for device
134	DUPKEYDET, Duplicate key detected
136	ILLILLACC, Illegal or illogical access
137	ILLKEYATT, Illegal key attributes
138	FILIS_LOC, File is locked
139	INVFILOPT, Invalid file options
141	ILLOPE, Illegal operation
142	ILLRECFIL, Illegal record on file
143	BADRECIDE, Bad record identifier
144	INVKEYREF, Invalid key of reference
145	KEYSIZTOO, Key size too large
146	TAPNOTANS, Tape not ANSI labelled
147	RECNUMEXC, RECORD number exceeds maximum
148	BADRECVAL, Bad RECORDSIZE value on OPEN
149	NOTENDFIL, Not at end of file

150 NO_PRIKEY, No primary key specified
151 KEYFIEBEY, Key field beyond end of record
152 ILLRECACC, Illogical record accessing
153 RECALREXI, Record already exists
154 RECBUCLOC, Record/bucket locked
155 RECNOTFOU, Record not found
156 SIZRECINV, Size of record invalid
157 RECFILTOO, Record on file too big
158 PRIKEYOUT, Primary key out of sequence
159 KEYLARTHA, Key larger than record
160 FILATTNOT, File attributes not matched
161 MOVOVEBUF, Move overflows buffer
162 CANNOT OPEN FILE
164 TERFORFIL, Terminal format file required
166 NEGFILSTR, Negative fill or string length
168 ILLALLCLA, Illegal ALLOW clause
170 INDNOTFUL, Index not fully optimized
171 RRVNOTFUL, RRV not fully updated,
173 INVRFAFIE, Invalid RFA field
174 FILEXPDAT, File expiration date not yet reached
175 NODNAMERR, Node name error
176 NEGTABNOT, Negative TAB not allowed
177 TOOMUCDAT, Too much data in record
178 ERRFILCOR, Error on OPEN - file corrupted
179 UNEFILDAT, Unexpired file date
181 DECERR, Decimal error or overflow
182 NETOPERR, Network operation error
183 REMOVEBUF, REMAP overflows buffer
185 RECOVEMAP, RECORDSIZE overflows MAP buffer
186 IMPERRHAN, Improper error handling
187 ILLRECLOC, Illegal record locking
189 TOOLITDAT, Too little data in record
190 ILLNETOPE, Illegal network operation

191 ILLTFFOPE, Illegal terminal-format file operation

192 ILLWAIVAL, Illegal wait value

193 DEADLOCK, Detected deadlock while waiting for GET or FIND

194 NOTBASIC, Not a BASIC error

195 DIMOUTRAN, Dimension number out of range

196 REMSTRNOT, REMAP string is not static

197 ARRTOOSMA, Array too small

226 GKSNOTINS, DEC GKS FOR VMS is not installed

227 STRTOOLON, String too long

228 RECATTNOT, Record attributes not matched

229 DIFUSELON, Differing use of LONG/WORD qualifiers

238 ARRMUSSAM, Arrays must be same dimension

239 ARRMUSSQU, Arrays must be square

240 CANCHAARR, Cannot change array dimensions

245 ILLEXIDEF, Illegal exit from DEF*

246 ERRTRANEE, ERROR trap needs RESUME

247 ILLRESSUB, Illegal RESUME to subroutine

250 NOTIMP, Not implemented

252 FILACPFAI, FILE ACP failure

253 DIRERR, Directive error

256 ECHTYPNOT, Prompt/echo type not supported

257 ILLTRANUM, Illegal transformation number

258 ILLPICOPE, Illegal picture operation

259 CLIPONOFF, Clipping must be ON or OFF

260 TRANOTDIF, Transformation numbers are not different

261 COLNOTCON, Color indices are not contiguous

262 ILLARESTY, Illegal area style

263 ILLTEXJUS, Illegal text justification

264 ILLTEXPRE, Illegal text precision

265 ILLTEXPAT, Illegal text path

266 ILLDEVID, Illegal device identification number

267 DEVTYPNOT, Device type is not supported

268 DEVNOTOPE, Device is not open

269	DEVOUTMET, Device is an output metafile
270	DEVINMET, Device is an input metafile
272	DEVOPEING, Device and operation are incompatible
273	COONOTNDC, Coordinates are not within NDC space
274	ILLLINSTY, Illegal line style number
275	ILLLINSIZ, Illegal line size
276	ILLPOISTY, Illegal point style number
277	ILLTEXRAT, Illegal text width-to-height ratio
278	ILLTEXHEI, Illegal text height
279	ILLSTYIND, Illegal area style index
280	ILLCOLIND, Illegal color index
281	NUMCOOINS, Number of coordinates is insufficient
282	UNINUMNOT, Unit number is not defined for the device
283	ILLECHARE, Illegal echo area
284	ILLINIVAL, Illegal initial value
285	ENTPOINOT, Entered points not within a transformation
286	UNKGKSERR, Unknown DEC GKS FOR VMS error
287	INVCHASTR, Invalid character in string
288	STRLENZER, String length is zero
289	DATOVERF, Data overflow
290	ILLCNTCLA, Illegal count clause
291	ILLCOLMIX, Illegal color mix
292	ILLDEVNAM, Illegal device name in OPEN
293	USEABOINP, User aborted input, locate point cancelled

B.3 Errors Not Generated By VAX BASIC

Table B–1 contains errors that cannot be generated in VAX BASIC. However, they can be displayed with the ERT$ function and are included for completeness.

Table B–1: Errors Not Generated by VAX BASIC

Number	Text
3	?Account or device in use
6	?Not a valid device
8	?Device not available
13	?User data error on device
16	?Name or account now exists
17	?Too many open files on unit
19	?Disk block is interlocked
20	?Pack ids don't match
21	?Disk pack is not mounted
22	?Disk pack is locked out
23	?Illegal cluster size
24	?Disk pack is private
25	?Disk pack needs 'cleaning'
26	?Fatal disk pack mount error
27	?I/O to detached keyboard
30	?Device not file-structured
32	?No buffer space available
33	?Odd address trap
34	?Reserved instruction trap
36	?SP stack overflow
37	?Disk error during swap
38	?Memory parity (or ECC) failure
39	?Magtape select error
40	?Magtape record length error
41	?Non-res run-time system
44	?Matrix or array too big
47	?Line too long
60	?Integer overflow, FOR loop
62	?No run-time system

(continued on next page)

Table B–1 (Cont.): Errors Not Generated by VAX BASIC

Number	Text
65	?Illegal MAGTAPE( ) usage
68-70	unused
71	?Statement not found
74	?Undefined function called
75	?Illegal symbol
76	?Illegal verb
77	?Illegal expression
78	?Illegal mode mixing
79	?Illegal IF statement
80	?Illegal conditional clause
81	?Illegal function name
82	?Illegal dummy variable
83	?Illegal FN redefinition
84	?Illegal line number(s)
85	?Modifier error
86	?Can't compile statement
87	?Expression too complicated
90	%Inconsistent function usage
91	?Illegal DEF nesting
92	?FOR without NEXT
93	?NEXT without FOR
94	?DEF without FNEND
95	?FNEND without DEF
96	?Literal string needed
98	?Syntax error
99	?String is needed
100	?Number is needed
106	%Inconsistent subscript use
107	?ON statement needs GOTO

(continued on next page)

Table B–1 (Cont.): Errors Not Generated by VAX BASIC

Number	Text
108	?End of statement not seen
109	?What?
110	?Bad line number pair
111	?Not enough available memory
112	?Execute only file
113	?Please use the run command
114	?Can't CONTinue
115	?File exists-RENAME/REPLACE
117	?Matrix or array without DIM
118	?Bad number in PRINT USING
119	?Illegal in immediate mode
120	?PRINT-USING buffer overflow
121	?Illegal statement
125	?Wrong math package
135	?Illegal usage
140	?Index not initialized
163	?No file name
165	?Cannot position to EOF
167	?Illegal record format
169	unused
172	?Record lock failed
180	?No support for operation in task
182	?Network operation rejected
184	?Unaligned REMAP variable
188	?UNLOCK EXPLICIT requires RECORDSIZE 512
198-225	unused
230	?No fields in image
231	?Illegal string image
232	?Null image

(continued on next page)

Table B–1 (Cont.): Errors Not Generated by VAX BASIC

Number	Text
233	?Illegal numeric image
234	?Numeric image for string
235	?String image for numeric
236	?TIME limit exceeded
237	?First arg to SEG$ greater than second
241	?Floating overflow
242	?Floating underflow
243	?CHAIN to nonexistent line number
244	?Exponentiation error
248	?Illegal return from subroutine
249	?Argument out of bounds
251	?Recursive subroutine call
254-255	unused
294-300	unused

Appendix C

Optional Programming Productivity Tools

This appendix provides an overview of optional programming productivity tools. These tools are not included with the VAX BASIC software; they must be purchased separately. Using these tools can increase your productivity as a VAX BASIC programmer. The following products are described in this appendix:

- VAX Language-Sensitive Editor (LSE) and VAX Source Code Analyzer (SCA) (Section C.1)
- VAX Common Data Dictionary Plus (CDD/Plus) (Section C.2)
- VAX Database Management System (VAX DBMS) (Section C.3)
- VAX DEC/Test Manager (Section C.4)
- VAX DEC/Code Management System (CMS) (Section C.5)

For information on how to purchase these tools, contact your DIGITAL sales representative.

C.1 VAX Language-Sensitive Editor (LSE) and the VAX Source Code Analyzer (SCA)

The VAX Language-Sensitive Editor (LSE) and the VAX Source Code Analyzer (SCA) must be purchased separately. LSE is a powerful and flexible text editor designed specifically for software development. LSE has important features that help you produce syntactically correct code in VAX BASIC. SCA is an interactive tool that is used to perform program analysis.

LSE and SCA are closely integrated products; generally, SCA can be invoked through LSE. LSE provides additional editing features that make SCA program analysis more efficient. In addition, LSE and SCA, in conjunction

with the VAX BASIC compiler, provide a set of new enhancements supporting source code designing and review.

In addition to text editing features, LSE provides the following software development features:

- Formatted language constructs, or templates, for most VAX programming languages, including VAX BASIC. These templates include the keywords and punctuation used in source programs, and use placeholders to indicate locations in the source code where additional text is optional or required.
- Commands to compile, review, and correct compilation errors from within the editor.
- Integration with VAX DEC/Code Management System (CMS). CMS commands can be issued from within the editor to make source file management more efficient.

SCA performs the following types of program analysis:

- Cross-referencing, which supplies information about program symbols and source files.
- Static analysis, which provides information on how subprograms, symbols, and files are related.

LSE and SCA together, in conjunction with the VAX language compilers, provide the following software design features:

- Pseudocode support, which includes a new LSE placeholder delimiter for delimiting pseudocode. Pseudocode is text that describes algorithms or design decisions. This feature allows you to write source code in shorthand, returning later to fill in code details.
- Comment processing, which includes design comment information in the SCA library. SCA performs cross-referencing and static analysis on this information in response to user queries.
- View support, which provides a reverse-design facility. LSE commands compress program code into overview line summaries. If you choose to edit these overview lines, the modifications you make are reflected in the program code.
- A report tool, callable through LSE, which can print views, standard design reports, and customized reports.

The following sections provide entry, exit, and language-specific information on the combined use of LSE and SCA.

For More Information:

- On LSE and SCA (*Guide to the VAX Language-Sensitive Editor and the VAX Source Code Analyzer*)
- On CMS (*Guide to VAX DEC/Code Management System*)

C.1.1 Preparing an SCA Library

SCA stores data generated by the VAX BASIC compiler in an SCA library. The data in the SCA library contains information about all symbols, modules, and files encountered during a specific compilation of the source. You must prepare this library before you enter LSE to invoke SCA. This preparation involves the following steps:

1. Create a VMS directory for your SCA library. For example:

   ```
   $ CREATE/DIRECTORY PROJ:[USER.LIB1]
   ```

2. Initialize and set the library with the SCA CREATE LIBRARY command. For example:

   ```
   $ CREATE LIBRARY [.LIB1]
   ```

   If you have an existing SCA library that has been initialized, you make its contents visible to SCA by setting it with the SCA SET LIBRARY command. For example:

   ```
   $ SCA SET LIBRARY [.EXISTING_SCA_LIBRARY]
   ```

   A message is displayed in the message buffer at the bottom of your screen indicating whether your SCA library selection succeeded.

3. Direct the VAX BASIC compiler to generate data analysis files by appending the /ANALYSIS_DATA qualifier to the VAX BASIC command. For example:

   ```
   $ BASIC/ANALYSIS_DATA PG1,PG2,PG3
   ```

   This command line compiles the input files PG1.BAS, PG2.BAS, and PG3.BAS, and generates corresponding output files for each input file with the file types OBJ and ANA. SCA puts these files in your current default directory.

4. Load the information in the data analysis files into your SCA library with the LOAD command. For example:

   ```
   $ SCA LOAD PG1,PG2,PG3
   ```

   This command loads your library with the modules contained in the data analysis files PG1.ANA, PG2.ANA, and PG3.ANA.

5. After the SCA library has been prepared, you enter LSE to begin an SCA session. Within this context, the integration of LSE and SCA provides commands that can be used only within LSE.

C.1.2 Starting and Terminating an LSE or an SCA Session

To invoke LSE, issue the following command at the DCL prompt:

```
$ LSEDIT USER.BAS
```

To end an LSE session, press CTRL/Z to get the LSE> prompt. If you want to save modifications to your file, issue the EXIT command. If you do not want to save the file or any modification to the file, issue the QUIT command.

To invoke SCA from LSE, type the SCA command that you want to execute at the LSE> prompt, as in the following syntax:

```
LSE> command [parameter] [/qualifier...]
```

To invoke SCA from the DCL command line for the execution of a single command, you can use the following syntax:

```
$ SCA command [parameter] [/qualifier...]
```

If you have several SCA commands to invoke, you may want to use the SCA subsystem to enter commands, as in the following syntax:

```
$ SCA
SCA>  command [parameter] [/qualifier...]
```

Typing EXIT (or pressing CTRL/Z) ends an SCA subsystem session and returns you to the DCL level.

C.1.3 Compiling from Within LSE

To compile a completed VAX BASIC program, issue the following command at the LSE prompt:

```
LSE> COMPILE
```

To compile a VAX BASIC program that contains placeholders and design comments, include the following qualifiers to the previous command:

```
LSE> COMPILE $/ANALYSIS_DATA/DESIGN=(PLACEHOLDERS, COMMENTS)
```

The /ANALYSIS_DATA qualifier causes the compiler to generate an analysis data file containing source code analysis information. This information is provided to the SCA library.

The /DESIGN qualifier instructs the VAX BASIC compiler to recognize placeholders and design comments as valid program elements. If the /ANALYSIS_DATA qualifier has also been specified, the VAX BASIC compiler includes information on placeholders and design comments in the analysis data file.

LSE provides several commands to help you review errors and examine your source code. Table C–1 lists these commands and their default key bindings where applicable.

Table C–1: LSE Commands Used to Examine Source Code

Command	Key Binding	Function
COMPILE	None	Compiles the contents of the source buffer. You can issue this command with the /REVIEW qualifier to put LSE in REVIEW mode immediately after the compilation.
REVIEW	None	Puts LSE into REVIEW mode, and displays any errors resulting from the last compilation.
END REVIEW	None	Removes the buffer $REVIEW from the screen; returns the cursor to a single window containing the source buffer.
GOTO SOURCE	CTRL/G	Moves the cursor to the source buffer that contains the error.
NEXT STEP	CTRL/F	Moves the cursor to the next error in the buffer $REVIEW.
PREVIOUS STEP	CTRL/B	Moves the cursor to the previous error in the buffer $REVIEW.
	{ Down arrow / Up arrow }	Moves the cursor within a buffer.

C.1.4 Notes on VAX BASIC Support

This section describes VAX BASIC-specific information for the following LSE and SCA features:

- Programming language placeholders and tokens
- Placeholder and design comment processing

C.1.4.1 Programming Language Placeholders and Tokens

LSE accepts keywords, or tokens, for all languages with LSE support. However, the specific tokens themselves are language defined. For example, you can expand the [MAT] token only when using VAX BASIC.

Likewise, LSE provides placeholders, or prompt markers, for all languages with LSE support. However, as with tokens, the specific text or choices these markers call for are language defined. For example, you see the [record-declarations] placeholder only when using VAX BASIC.

NOTE

> Keywords such as TYPE, VARIANT, IF, FOR, and OPEN, can be tokens as well as placeholders. Therefore, any time you are in LSE with the language set to VAX BASIC, you can type one of these words and press CTRL/E to expand the construct.

Remember that braces ({}) enclose required placeholders and brackets ([ ]) enclose optional placeholders. Note that when you erase an optional placeholder, LSE also deletes any associated text before and after that placeholder.

You can use the SHOW TOKEN and SHOW PLACEHOLDER commands to display a list of all VAX BASIC tokens and placeholders, or a particular token or placeholder. For example:

```
LSE> SHOW TOKEN IF              {lists the token IF}
LSE> SHOW TOKEN                 {lists all tokens}
```

To copy the listed information into a separate file, first issue the appropriate SHOW command to put the list into the $SHOW buffer. Next, issue the following command:

```
LSE> GOTO BUFFER $SHOW
LSE> WRITE filename.filetype
```

To obtain a hard copy of the list, use the PRINT command at DCL level to print the file you created.

C.1.4.2 Placeholder and Design Comment Processing

While all languages with Version 3.0 of LSE support provide placeholder processing, each language defines specific contexts in which placeholders can be accepted as valid program code. The following list contains valid contexts in which placeholder processing is allowed.

- User identifiers in EXTERNAL statements

- Names of RECORD types
- Data types of a FUNCTION in a FUNCTION declaration
- Data types in a DECLARE statement
- Entire statements
- Comments

VAX BASIC accepts optional LSE placeholders in any context where optional syntax is allowed. Example C–1 shows several contexts in which LSE placeholders and design comments might appear in the design of a VAX BASIC program.

Example C–1: LSE Placeholders in a VAX BASIC Program

```
!++
!   FUNCTIONAL DESCRIPTION:
!
!     This procedure computes the amount of an employee's salary and prints
!     a paycheck.
!
!   FORMAL PARAMETERS:
!
!     name -
!         The name of the employee, last name first.
!
!
!
!--
    DECLARE INTEGER weekly_salary

    <<Fetch the employee's record.>>;

!+
!     Compute paychecks differently for salaried and hourly employees.
!-
     If <<employee is salaried>>
     THEN
        <<Use a fixed weekly salary from the employee's record.>>
     ELSE
        <<Fetch the number of regular and overtime hours worked.>>;
        <<Compute the weekly pay.>>
     END IF;

     <<Print the paycheck>>
     END SUBPROGRAM paycheck
```

VAX BASIC support for placeholder and design comment processing includes the following language-specific stipulations:

- Pseudocode placeholders are designated with double right- and left-angle brackets, << >> or « ».
- Comment processing is limited to the header and declarative sections of each compilation unit.

Placeholders can be either required or optional. Required placeholders, which are delimited by braces ({}), represent places in the source code where you must provide program text. Optional placeholders, which are delimited by brackets ([ ]), represent places in the source code where you can either provide additional constructs or delete the placeholder.

Additionally, when you use VAX BASIC with LSE, the expanded code might include ellipses (...) or vertical bars (|). Syntax constructs followed by ellipses indicate that the constructs can be repeated. A vertical bar between constructs indicates that you must choose one of the constructs.

Table C–2 lists the three types of LSE placeholders.

Table C–2: Types of LSE Placeholders

Type of Placeholder	Description
Terminal	Provides text strings that describe valid replacements for the placeholder
Nonterminal	Expands into additional language constructs
Menu	Provides a list of options corresponding to the placeholder

LSE commands allow you to manipulate tokens and placeholders. These commands and their default key bindings are listed in Table C–3.

Table C–3: LSE Commands Used to Manipulate Tokens and Placeholders

Command	Key Binding	Function
EXPAND	CTRL/E	Expands a placeholder
UNEXPAND	PF1-CTRL/E	Reverses the effect of the most recent placeholder expansion
GOTO PLACEHOLDER/FORWARD	CTRL/N	Moves the cursor to the next placeholder
GOTO PLACEHOLDER/REVERSE	CTRL/P	Moves the cursor to the previous placeholder
ERASE PLACEHOLDER/FORWARD	CTRL/K	Erases a placeholder
UNERASE PLACEHOLDER	PF1-CTRL/K	Restores the most recently erased placeholder
None	Down arrow	Moves the indicator down through a menu
None	Up arrow	Moves the indicator up through a menu
None	{ ENTER RETURN }	Selects a menu option

C.1.5 LSE and SCA Examples

The following examples show how you can use a few common tokens and placeholders to write VAX BASIC code. The examples are expanded to show the formats and guidelines LSE provides. However, not all of the examples are fully expanded.

The examples show expansion of the following VAX BASIC features:

- FUNCTION declaration
- FIND statement
- FOR statement

Instructions and explanations precede each example. See Table C–1 for the commands that manipulate tokens and placeholders.

To reproduce the examples in the following sections, invoke LSE and the VAX BASIC language by specifying the following command:

```
$ LSEDIT TRYLSE.BAS
```

C.1.5.1 FUNCTION Declaration

This section provides an example of how to use LSE to create a FUNCTION declaration.

When you are creating a new program using LSE, the initial string, [compilation_unit], appears at the top of the screen. Expand the placeholder [compilation_unit] by pressing CTRL/E. A menu appears on your screen. Select the option FUNCTION by using the down arrow key and pressing RETURN. The following is displayed on your screen:

```
[title-ident-info]
FUNCTION {data-type} {func-name} [bas-pass-mech] [decl-formal-param-list]

![function_header]
    [option]
    [declarations]
    {statement}...

END FUNCTION [result-exp]  ! End of FUNCTION {func-name}
```

Erase placeholder [title-ident-info]. Type WORD over placeholder {data-type} and type find_user over placeholder {func-name}.

```
FUNCTION WORD find_user [bas-pass-mech] [decl-formal-param-list]
![function_header]
    [option]
    [declarations]
    {statement}...

END FUNCTION [result-exp]  ! End of FUNCTION {func-name}
```

Erase placeholder [bas-pass-mech]. Expand placeholder [decl-formal-param-list], and expand placeholder [formal-param] to display a menu. Select option {non-string-unsubs} from the menu.

```
FUNCTION WORD find_user ({non-str-data-type} {unsubs-vbl-name} [BY REF],
[formal-param]...)
![function_header]
    [option]
    [declarations]
    {statement}...

END FUNCTION [result-exp]  ! End of FUNCTION find_user
```

Type INTEGER over placeholder {non-str-data-type}. Type user_no over {unsubs-vbl-name}. Erase placeholders [BY REF] and [formal-param].

```
FUNCTION WORD find_user (INTEGER user_no)
![function_header]
     [option]
     [declarations]
     {statement}...

END FUNCTION [result-exp]   ! End of FUNCTION find_user
```

Erase placeholder [function_header] and expand placeholder [option]. Expand placeholder {option_clause} to display a menu and select the option TYPE.

```
FUNCTION WORD find_user (INTEGER user_no)
     OPTION TYPE = {type-clause}, &
              [option-clause]...

     [declarations]
     {statement}...

END FUNCTION [result-exp]   ! End of FUNCTION find_user
```

Expand placeholder {type-clause} to display a menu and select the option INTEGER. Erase placeholders [option-clause] and [declarations].

```
FUNCTION WORD find_user (INTEGER user_no)
     OPTION TYPE = INTEGER
     (statement}...

END FUNCTION [result-exp]   ! End of FUNCTION find_user
```

Note that when you erase an optional placeholder, LSE also deletes any associated text before and after that placeholder.

C.1.5.2 FIND Statement

This section provides an example of how to use LSE to create a FIND statement.

```
FUNCTION WORD find_user (INTEGER user_no)
     OPTION TYPE = INTEGER
     {statement}...

END FUNCTION [result-exp]   ! End of FUNCTION find_user
```

Expand {statement} to display a menu and select the option FIND.

```
FUNCTION WORD find_user (INTEGER user_no)
     OPTION TYPE = INTEGER
     FIND #{chnl-exp}, [position-clause], [lock-clause]

END FUNCTION [result-exp]   ! End of FUNCTION find_user
```

Expand placeholder {chnl-exp}, and type 3 over placeholder {num-exp}. Expand placeholder [position-clause] to display a menu and select the option KEY.

```
FUNCTION WORD find_user (INTEGER user_no)
    OPTION TYPE = INTEGER
    FIND #3, KEY #{int-exp} {sym-rel-op} {key-oprnd}, [lock-clause]
    [statement]...

END FUNCTION [result-exp]  ! End of FUNCTION find_user
```

Type 0 over placeholder {int-exp}. Expand placeholder {sym-rel-op} to display a menu and select the option EQ. Type "JONE" over placeholder {key-oprnd}.

```
FUNCTION WORD find_user (INTEGER user_no)
    OPTION TYPE = INTEGER
    FIND #3, KEY #0 EQ "JONE", [lock-clause]
    [statement]...

END FUNCTION [result-exp]  ! End of FUNCTION find_user
```

Expand placeholder [lock-clause] to display a menu and select option "ALLOW {allow-clause} [opt-wait-clause]". Expand placeholder {allow-clause} to display a menu and select option READ. Expand option [opt-wait-clause] and type 25 over [lock-timeout-exp].

```
FUNCTION WORD find_user (INTEGER user_no)
    OPTION TYPE = INTEGER
    FIND #3, KEY #0 EQ "JONE", ALLOW READ , WAIT 25
    [statement]...

END FUNCTION [result-exp]  ! End of FUNCTION find_user
```

C.1.5.3 FOR Statement

This section provides an example of how to use LSE to create a FOR statement.

```
FUNCTION WORD find_user (INTEGER user_no)
    OPTION TYPE = INTEGER
    {statement}...

END FUNCTION [result-exp]  ! End of FUNCTION find_user
```

Expand placeholder {statement} to display a menu and choose the option FOR. Then choose the option FOR-TO.

```
FUNCTION WORD find_user (INTEGER user_no)
    OPTION TYPE = INTEGER
    FOR {for-num-index-name} = {num-exp} TO {num-exp} STEP [step-exp]
        {statement}...
    NEXT {for-num-index-name}
    [statement]...

END FUNCTION [result-exp]  ! End of FUNCTION find_user
```

Type INT_INDEX over placeholder {for-num-index-name}, and type 1 over placeholder {num-exp}.

```
FUNCTION WORD find_user (INTEGER user_no)
    OPTION TYPE = INTEGER
    FOR INT_INDEX = 1 TO {num-exp} STEP [step-exp]
        {statement}...
    NEXT INT_INDEX

    [statement]...

END FUNCTION [result-exp]  ! End of FUNCTION find_user
```

Type 10 over placeholder {num-exp} and type 2 over placeholder [step-exp]. Type SUM=SUM + INT_INDEX over placeholder {statement}.

```
FUNCTION WORD find_user (INTEGER user_no)
    OPTION TYPE = INTEGER

    FOR INT_INDEX = 1 TO 10 STEP 2
        SUM = SUM + INT_INDEX
        [statement]...
    NEXT INT_INDEX

    [statement]...

END FUNCTION [result-exp]  ! End of FUNCTION find_user
```

At this point the program is complete. You can then issue the LSE COMPILE command to compile the contents of the buffer without exiting from the LSE editing session. After you exit the LSE editing session, you can then link and run the program.

C.2 VAX CDD/Plus

VAX BASIC supports CDD/Plus. CDD/Plus is a new version of the VAX Common Data Dictionary (CDD) that is completely compatible with previous versions of CDD, while providing new features such as the ability to create field definitions and the ability to track the use of dictionary entities.

See Chapter 23 for more information on CDD/Plus.

C.3 VAX Database Management System (VAX DBMS)

The VAX Database Management System is a multiuser general-purpose CODASYL-compliant database management system. The VAX Database Management System is used for accessing and administrating databases ranging in complexity from simple hierarchies to complex networks with multilevel relationships. The VAX Database Management System supports

full concurrent access in a multiuser environment without compromising the integrity and security of your database.

The VAX Database Management System features include the following:

- Full concurrent access in a multiuser environment
- Record locking and journaling
- Automatic transaction and verb rollback
- Multiple-database support (one or more databases for processing)
- Online backup
- Integration with CDD/Plus
- Schema, subschema, storage schema, and security schema data definition languages (DDLs)

For more information, refer to the VAX Database Management System documentation.

C.4 VAX DEC/Test Manager

The VAX DEC/Test Manager helps test software during development and maintenance. This tool automates the organization, execution, and review of tests and allows several developers to use one set of tests at the same time.

With the VAX DEC/Test Manager, you can describe your tests, organize them by assigning them to groups, and choose combinations of tests to run by test name or by group. The VAX DEC/Test Manager executes the tests selected and then compares the result with the expected results.

For more information, refer to the VAX DEC/Test Manager documentation.

C.5 VAX DEC/Code Management System (CMS)

The VAX DEC/Code Management System (CMS) is a program librarian for software development and evolution. It is comprised of a set of commands that enable you to manage files of an ongoing project.

CMS enables you to do the following tasks:

- Store ASCII text files in a project library
- Retrieve previous generations of files stored in CMS
- Obtain a report of file modifications, including when, why, and by whom the modifications were made

- Determine the origin of each line of a file, either as an annotated listing or as comments in the file
- Manage concurrent modifications and merge separately developed modifications
- Store related files together as a single element
- Relate the generation of one element to the corresponding generations of other elements

For more information on CMS, refer to the VAX DEC/Code Management System documentation.

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Clarity (easy to understand)	☐	☐	☐	☐
Organization (structure of subject matter)	☐	☐	☐	☐
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Figures (useful)	☐	☐	☐	☐
Examples (useful)	☐	☐	☐	☐
Index (ability to find topic)	☐	☐	☐	☐
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